Underground Test Coordination at the Waste Isolation Pilot Plant - 15229

Douglas J. Weaver[1], Roger A. Nelson[2], and Brian L. Dozier[3]

[1]*Los Alamos National Laboratory, Carlsbad, New Mexico, douglas_weaver@lanl.gov*
[2]*U.S. DOE Carlsbad Field Office, Carlsbad, New Mexico, Roger.Nelson@cbfo.doe.gov*
[3]*Los Alamos National Laboratory, Carlsbad, New Mexico, dozier@lanl.gov*

ABSTRACT

Underground test coordination is a critical component of safe and efficient conduct of testing operations in a working underground research laboratory (URL). This is particularly important when planning and implementing large, multi-organizational field-scale test programs, when the URL is co-located with an operating repository, or when the host facility, such as the Waste Isolation Pilot Plant (WIPP), is recovering from off-normal events. As such, the Department of Energy Carlsbad Field Office developed an Integrated Project Team (IPT) charter in late 2013 establishing the WIPP underground Test Coordination Office (TCO). The IPT was established to ensure that underground science activities are coordinated, implemented, and managed in an integrated, consistent, efficient, cost-effective, safe, and environmentally compliant manner that maintains quality assurance standards. This is done while ensuring testing operations do not interfere with the WIPP's primary mission, the disposal of transuranic (TRU) waste, and at present, the recovery of WIPP operations.

This paper reports the current status of the WIPP underground science and testing programs within the framework of the WIPP stabilization and recovery activities and describes the role of the TCO for current activities as well as for the long-term success of an underground research laboratory. As a result of the underground fire and radiological incident of early February 2014, during this recent period of WIPP recovery, the TCO is ensuring the requirements of the scientific programs are met and that work activities are planned and implemented in compliance with enhanced work control processes and corrective actions imposed at WIPP. This paper addresses the impacts of the accidents at WIPP on the many science experiments that were in process when the events occurred. It presents the plans for their recovery in concert with WIPP's recovery plans, and summarizes the impacts of new underground processes and procedures that will be imposed on the science work as a result.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is principally designed and operated as a deep geologic repository for permanent isolation of long-lived radioactive waste. It is also host to a number of experiments that take advantage of the unique environmental characteristics found in an underground salt formation, such as the absence or minimization of naturally occurring radioactive elements, and shielding from cosmic rays by the overlying rock. In addition, the WIPP provides a platform for field-scale tests of salt repository performance for waste forms other than the transuranic (TRU) waste for which it is currently authorized. Planning and design for large-scale heater tests in the newly mined underground research area of the WIPP is progressing, and proposals for other in-situ tests are being formulated [1][2][3].

Due to the size, duration, and complexity of the science and testing activities in the WIPP underground, and with plans for large, multi-organizational field-scale test programs in the future, an Integrated Project Team (IPT) charter was approved in November 2013 by the Department of Energy Carlsbad Field Office. The charter establishes the WIPP underground Test Coordination Office (TCO) to ensure that underground science activities are coordinated, implemented, and managed in an integrated, consistent, efficient, cost-effective, safe, and environmentally compliant manner. The TCO also helps to ensure, through rigorous planning, scheduling, consistent site-interface, and work requests that the science activities do not interfere with the WIPP's primary mission, the disposal of transuranic (TRU) waste. This model of test coordination has been developed and refined over decades of involvement and leadership in nuclear repository science projects, including the Yucca Mountain Repository Project, and activities at the Nevada National Security Site. This management system is particularly critical in the stabilization and recovery efforts following off-normal events such as the fire and radiation events of early February 2014 at WIPP.

BRIEF HISTORY OF TEST COORDINATION IN REPOSITORY BASED UNDERGROUND RESEARCH LABORATORIES

The role of test coordination in underground research laboratories (URLs) in a radioactive-waste repository setting was formalized in the United States in the late 1980's on the Yucca Mountain Nuclear Repository Project (YMRP) in Nevada. The organization was initially formed to spearhead the development of test planning packages for the proposed site characterization program in development at Yucca Mountain. This group provided a comprehensive capability to refine, coordinate, integrate, implement, and document underground testing programs involving multiple test organizations, operations, contractors, and DOE management. In this phase of the project, the TCO was primarily responsible for consolidating test criteria from the principal investigators, developing test facility requirements with the architect/engineering organizations, defining the construction and other test support needs, incorporating regulatory and safety requirements, and finally, defining and documenting potential test-to-test interference impacts.

As the YMRP matured and plans for construction of an 8 kilometer long exploratory studies facility and associated cross-drift advanced, the group expanded to refine test scopes, develop cost and schedule details for each testing element, and develop a field office for the implementation and oversight of the underground test program. This role eventually broadened to cover all YMRP related test activities including surface-based drilling, geotechnical work, laboratory studies at the national laboratories and universities, and ownership of test-related programmatic processes such as control of measuring and test equipment, scientific notebooks, underground geologic samples, and test plans.

The organization was staffed with personnel who exhibited strong technical understanding of a geologic testing program with backgrounds and university degrees in geology, physics, engineering, and other science-based fields. The staff possessed unique skills (largely derived from the underground nuclear weapons testing experience on the Nevada Test Site) to coordinate testing programs in a construction, mining, and engineering environment. In other words, TCO staff need to be skilled at field work (in particular, underground work), yet have the technical expertise to work with scientists and investigators to ensure the functional and operational requirements for their specific projects are planned and conducted to pre-defined quality assurance, technical, and site-imposed standards.

Pursuant to the cessation of technical activity at the YMRP in 2010, technical staff from this unique organization relocated from Nevada to WIPP in support of the current science program and future salt investigations. In 2013, the DOE Carlsbad Field Office (CBFO) established this underground test coordination role in an IPT charter [4].

OVERVIEW AND IMPACTS OF RECENT WIPP INCIDENTS ON THE SCIENCE PROGRAM

Two isolated events took place at the WIPP in February, 2014 that dramatically curtailed underground access and support to the experiments within WIPP. Figure 1 illustrates the location of the two underground events in relation to the underground science program and other features in the WIPP underground.

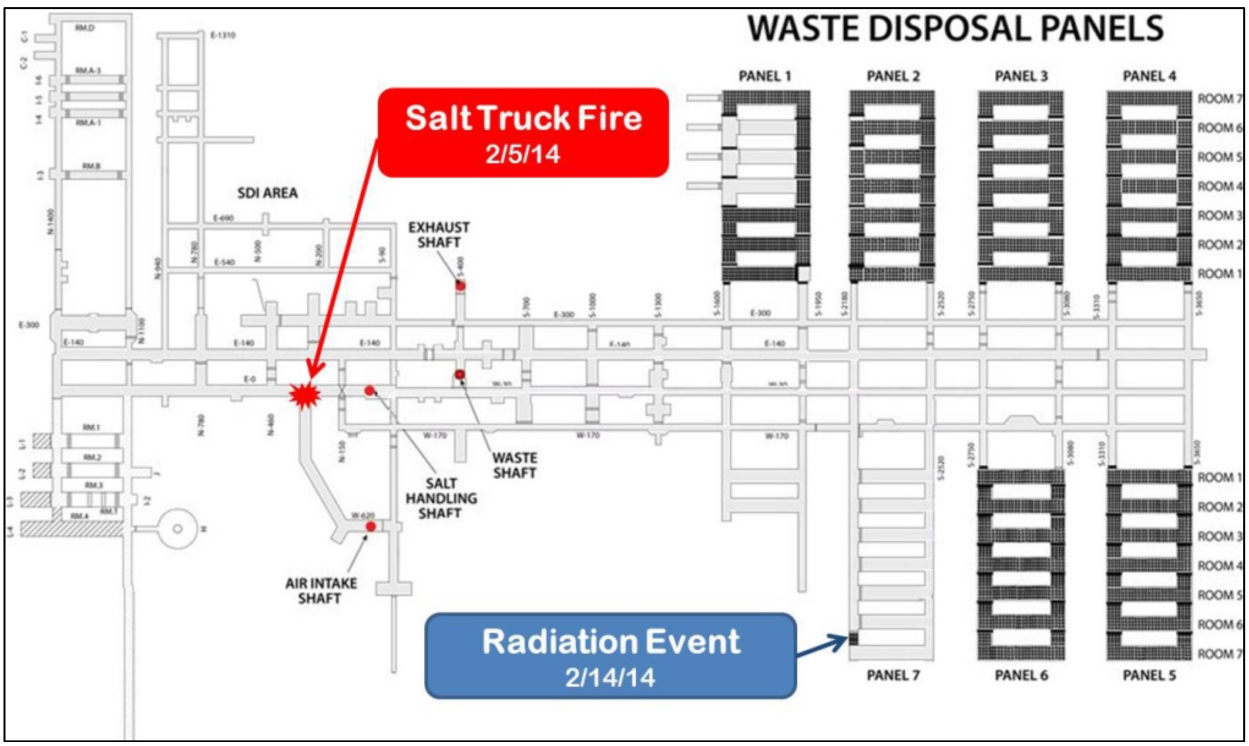

Fig. 1. Location of WIPP Events in the Underground

On February 5, 2014, at approximately 10:45 am, an underground fire occurred involving a salt haul truck. The EIMCO Model 985, 15 ton haul truck, is a diesel powered vehicle used to haul salt from the mine to the salt shaft. The fire unfortunately occurred at the intersection of the primary air intake and the main ventilation split that sends air to the north and south areas of the mine. This fanned the fire, which burned the engine compartment and the front tires to extinction. Extensive soot resulted and flooded both north and south ends of the underground. Workers were evacuated, and the underground portion of WIPP was shut down. Figure 2 shows the burned truck and an example of soot deposit on the surfaces in the north experimental area of WIPP. Significant to the long term recovery of WIPP, the fire resulted in soot being deposited on the mine’s walls, shafts, and underground equipment, including the waste hoist tower. The results of the fire accident investigation were released in an extensive report issued March 13, 2014 [5].

Fig. 2. Photos of Truck Fire and Soot Deposited on Surfaces in North Experimental Area of WIPP

Nine days later, at 11:14 pm on February 14, 2014, a second event occurred when a continuous air monitor (CAM) located near the Panel 7 emplacement drift in the WIPP underground alarmed. No personnel were underground at the time. The CAM measured airborne radioactivity close to the location where waste was being emplaced. When the CAM alarmed, WIPP exhaust air was redirected through high efficiency particulate air (HEPA) filters that remove radioactive particles. As a result of the radiological event, portions of the WIPP underground and the existing surface mounted ventilation system are radiologically contaminated. Since the radiological release, the underground ventilation system has operated in filtration mode through two parallel HEPA filter banks with an air flow rate of 1,700 cubic meters per minute of filtered air, which is significantly lower than the nominal pre-incident flow rate of 12,000 cubic meters per minute. [6]. The current limited ventilation constrains the number of personnel and activities that can be conducted in the underground at any time. Operations impacted include activities that produce exhaust or fumes (e.g., diesel engines for roof bolters, fork lifts, salt haul trucks, underground construction vehicles) and create underground dust (e.g., mining, roof bolting, vehicle movements, movement of salt). The first phase of the radiological accident investigation is complete, and the results are documented in the comprehensive report issued April 24, 2014 [7]. Phase 2 of the investigation of the radiological release is in process and focuses on the cause of the radiological release.

Following the fire incident, underground access was limited to essential activities until the event could be investigated. At the time of the fire, the active underground experimental programs, namely the Enriched Xenon Observatory experiment, were left in a suspended condition with air conditioning units running and calibrations in process. The TCO planned and conducted an underground entry with scientific staff to the north experimental area on February 13, 2014 to plan for activities that would place the experiment in a long term stable condition.

After the radiological incident of February 14, no underground entries were allowed until the event was investigated and the underground conditions determined to be safe. The first entry to the north experimental area with scientific staff was conducted on August 21, 2014 to survey the conditions and inspect critical test components. Following that initial entry, access to the underground for TCO and scientific staff was obtained several times per week to conduct time-sensitive stabilization activities on the operating test equipment. Underground access is currently limited to a maximum of 74 persons until the waste hoist can be void of water accumulated in the hoist sump, inspected, and brought back into service. This limited number, due to emergency underground egress requirements, results in prioritization of the underground work and at times, limits the number and duration of entries to the experimental areas. Availability of the waste hoist for personnel will allow WIPP to increase the overall number of employees that can be in the underground facility at one time and provide an additional means of entry and egress.

On September 12, 2014, power to the underground was lost due to a storm in the immediate area. Because of the amount of soot in the north experimental area, power centers and switches will not be turned-on until each is inspected and cleaned as appropriate. All air conditioning, external monitoring, and other critical systems in the experimental program are currently de-energized. As a result, several entries have been made to place the experiments in safe and stable condition until power can be restored. This includes shutting off valves and venting pressure differentials in the scientific detector systems to prevent the loss of expensive and virtually irreplaceable enriched Xenon used in the experiments.

On September 30, 2014, the US DOE released the WIPP Recovery Plan [6] outlining the necessary steps and schedule to resume operations at the WIPP site. This Recovery Plan summarizes the strategy, key activities, and management approach to safely return WIPP to its mission of TRU waste disposal operations and to safely recover and return to operability the underground science program.

Systematically, the underground is being made habitable for safe operations. Operations will include simultaneous activities in contaminated and uncontaminated sections of the mine. Comprehensive underground surveys are ongoing to determine the extent of the contamination. The zone which includes the science activities in the northern portion of WIPP as well as the newly mined underground research area has been deemed free of contamination. Ventilation will eventually be increased in phases back to its pre-incident airflow capacity.

As of the time of writing this paper, a limited number of diesel-powered equipment is being returned to service in the underground. The WIPP personnel are completing final inspection of the waste hoist which is anticipated to be back in service within weeks. Power to the northern area of WIPP and the science programs is expected to be inspected, cleaned as necessary, and returned to service within weeks. Bolting and other ground support activities are resuming. Vacuuming and cleaning of soot from the experimental areas is commencing and planning for the leveling of the experimental structures due to salt creep is beginning. Additional information concerning the February accidents can be found in paper 14024 being presented at Waste Management 2015 [8].

ROLE OF TEST COORDINATION WITHIN THE FRAMEWORK OF WIPP STABILIZATION AND RECOVERY

Safety is paramount to the overall strategy of recovery at WIPP. The accident reports for the underground fire and the radiological release identified a number of weaknesses with the WIPP safety programs [5][7]. Taking into account these identified deficiencies, safety documentation is actively being revised and upgraded to required standards. Recovery will proceed at a safe pace, commensurate with workforce capabilities, mine conditions, and status of WIPP infrastructure and systems [6]. Every stage of recovery will be supported by rigorous regulatory compliance and robust upgrades to nuclear safety, fire protection, radiological controls, emergency management, work control, scheduling, and associated documentation, procedures, and training. Specific examples of newly implemented changes to the work control and conduct of operations processes include an improved formality of hazards analyses for complex or non-routine work activities, active fire watches for each underground team, and enhanced underground training with an emphasis on donning and doffing self-rescuers.

In light of this emphasis, it is imperative that the science and testing community are supported by an organization with staff that are cognizant of the changes to site processes, the new standards their work will be subject to, and that can assist in the development of the products that will be required to fully resume science operations underground at WIPP. Therefore, the TCO has taken the processes and procedures exercised over decades of testing in underground research laboratories and repository settings, and have refined a tailored work control system under the principles and functions of the DOE Integrated Safety Management System that specifically address the unique job descriptions, hazard identification, and hazard mitigation techniques for research and development oriented workscope [9]. Because visits by most of the scientific staff are generally infrequent to the WIPP, it is essential to have an organization on-site and dedicated to the unique needs of a testing organization including work planning, training, general underground support, underground escort, and daily scheduling of the test activities with WIPP operations and recovery efforts. Other specific issues that must be addressed in the upfront planning and coordination of the WIPP underground research include test sequencing, evaluation of potential test-to-test interference, data acquisition, and underground work control and infrastructure management.

Specifically, the TCO-developed test specific work control system is integrated with the processes prescribed by the WIPP contractor. The core of the process specifies the development of science specific work authorization packages that provide detailed work definition, hazard analysis, and hazard controls that are uniform, consistent, and site-specific. This documentation is developed using an iterative process involving TCO staff, the principal investigators, the workers, and WIPP operations staff, as appropriate. Worker involvement is key in the development of these packages and is necessary to identify the most efficient and safe methods to accomplish the workscope. The hazard analysis and mitigation process is routinely accomplished by invoking subject matter experts in the area to assist in identifying, grading, and mitigating the test and facility specific hazards. Because the recovery process at WIPP is evolving and new hazards are being identified or mitigated each day, it is important test coordination staff routinely evaluate the job hazards database and attend daily coordination meetings to ensure the latest information is present in the package.

Once the work authorization package is finalized, reviewed and approved by TCO staff, science management, and multiple disciplines at the WIPP, the package is released for work and placed on the weekly schedule for implementation. The TCO is responsible to conduct and document a pre-job meeting with the performers of the work and other affected parties to ensure integration across multiple-organizations or co-located work activities. As the field work commences, TCO staff coordinates the underground access, support services, and oversees the field testing activities to ensure compliance with the approved documentation. This oversight ensures that work activities are being performed within controls, employee feedback is captured, and ensures continuous improvement in planning future work activities. The frequency of coordination and oversight is determined by the complexity of the testing activity, the anticipated hazards involved, and the interval of time passed since the last oversight. Once the work is complete, a post-job meeting is conducted to document worker feedback on the activity. The oversight and post-job functions of this process are essential to complying with the core functions of Integrated Safety Management.

The science-tailored work authorization process is flexible and expected to evolve as underground access and work requirements change through the recovery process. The TCO will continue to ensure that CBFO-funded science and testing activities in the WIPP underground generate test-related information and data that are of high-quality, and that all testing activities are well coordinated, focused, and safe, particularly when multiple organizations are involved and in times of off-normal conditions.

STATUS OF THE WIPP UNDERGROUND SCIENCE AND TESTING PROGRAMS AND PATH TO RECOVERY

In addition to the TRU waste disposal mission at WIPP, the underground facility also provides a unique capability for basic science and research. Experiments that require a very low background radiation environment are being performed in the underground research facility at the WIPP site. Levels of naturally occurring radioactivity (e.g., uranium and thorium) are very low in the salt formation. In addition, WIPP’s depth (667 meters, 2150 feet) also provides substantial shielding from cosmic rays. The WIPP provides an ideal environment for experiments in many scientific disciplines, including particle astrophysics, waste repository science, mining technology, low-radiation-dose physics, biology, fissile materials accountability and transparency, and deep geophysics. The WIPP offers its mine operations infrastructure and space in the underground to researchers who require this unique environment for their tests.

The experimental programs currently in operation at the WIPP include the Segmented Enriched Germanium Assembly (SEGA) and Multiple Element Germanium Array (MEGA) experiments being conducted near Q-Room and, in the northern end of the WIPP facility, the Enriched Xenon Observatory (EXO) experiment, the Low-Background Radiation Experiment (LBRE), and the Dark Matter Time Projection Chamber (DMTPC) experiment. Additionally, over 2000 meters of new mining to gain access in the northeastern area of WIPP was completed in February 2014. This underground research area is planned to be used to investigate the effects of relatively low-temperature simulated heat-generating waste [10]. The primary goals for full scale heater tests of an in-drift emplacement concept focus on understanding the fate and transport of brine trapped within the formation. Furthermore, salt sampling activities were routinely conducted in the WIPP underground to provide specimens for laboratory analysis, including thermal-mechanical investigations, hydrological studies, and bacterial investigations. Occasionally, these sampling activities would be complex and labor-intensive, using core rigs or mechanical miners to obtain large-diameter cores and blocks for analysis. Figure 3 shows the relative locations of these science experiments and activities within WIPP.

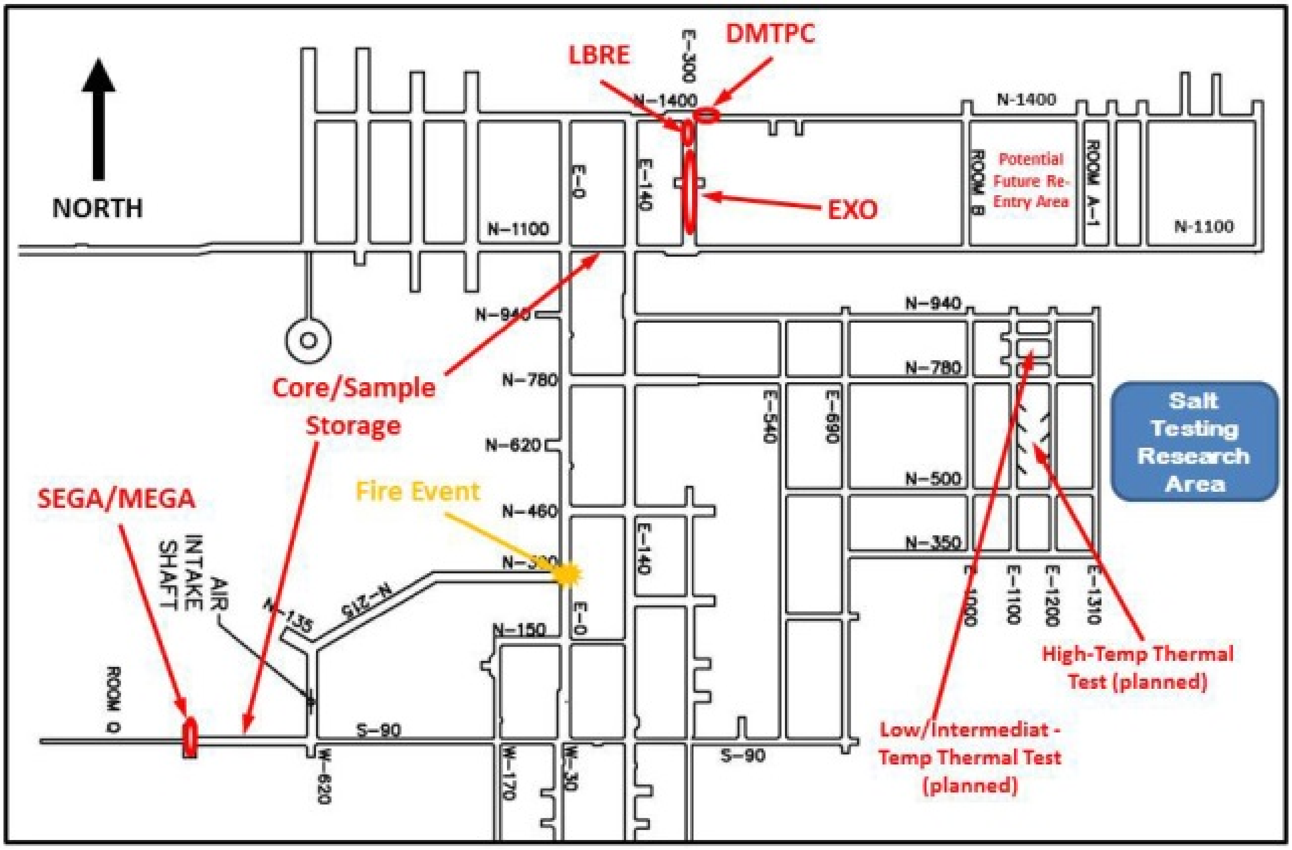

Fig. 3. Location of Science Experiments within WIPP

The subsections below provide a brief explanation of each science program in progress at the time of the February incidents, their current status, and any unique impacts or recovery actions required as a result.

The Enriched Xenon Observatory (EXO) Experiment

EXO is an experiment designed to identify neutrinoless double beta decay of the Xe-136 isotope. The experiment currently consists of a 200-kilogram prototype experiment and has measured for the first time the two-neutrino mode of double beta decay of Xe-136. It has also set the most stringent limit on the rate of neutrinoless double beta decay and it continues to collect data in order to improve on this limit or potentially discover the decay. These are important observations for two reasons. First, it is unknown if the neutrino is its own antiparticle or not, and seeing it would definitively answer the question. Second, the exact mass of the neutrino and a measurement of the neutrinoless double beta decay half-life are unknown but would allow for the assessment of the neutrino mass. Even if neutrinoless double beta decay is not observed, a limit on the half-life places a limit on the neutrino mass [11].

Modules for the EXO arrived in the WIPP underground in 2007. They are stationed in the northern end of WIPP between the N-1100 and N-1400 drifts. EXO is the largest of the currently operating basic science physics experiments at WIPP, using the largest non-fissile enriched isotopic mass in the world for determining the mass of the neutrino. Pending the timely recovery of the WIPP operations and infrastructure support, the EXO collaboration (led by Stanford University) plans to continue operations using the 200 kilogram scale detector for several more years. Figure 4 is a picture of EXO investigators in the clean-room in front of the detector.

Fig. 4. EXO investigators in the clean-room in front of the detector

The impacts to the EXO experiment resulting from the WIPP incidents were greatest of all the WIPP underground testing programs and the recovery actions most complex. EXO was in full operation and staff was underground at the time of the fire incident. With no physical entry to the EXO experiment until late August, 2014, investigators remotely captured the precious enriched Xenon into bottles. They continued to remotely monitor the test conditions from the surface until power was lost in September, 2014. Underground entries to the test have concentrated on venting the expanding coolants within the detector system to prevent damage to the detector, shutting off valves to the system to prevent soot and dust contamination from entering the test chambers and pipes, taking swipes of the clean room surfaces to determine levels of contamination, and configuring electrical loads in preparation for power restoration to the area. In addition, recent entries have concentrated on cleaning soot from scientific equipment using cleaning agents and vacuums.

Because of the creep rate of the host rock at WIPP (bedded salt), the clean room segments of the structure housing the equipment are moving out of level. Work authorization packages are developed by TCO and EXO staff for the leveling of the structures associated with this test and for maintenance work on the air handling and conditioning equipment, imperative for positive pressure to the experiment to maintain the clean room status.

The Low Background Radiation Experiment (LBRE)

The aim of the Low Background Radiation Experiment (LBRE) is to investigate the effects of low levels of radiation on biological systems. Background radiation on earth is ubiquitous and all organisms have developed mechanisms to cope with its negative effects. A debate exists on the threshold for these negative effects, in great part because government regulations regarding exposure to radiation assume that there is no safe level and that any amount above naturally occurring levels translates into deleterious effects. Because of the known negative effects of high levels of radiation on biological systems, scientific and regulatory agencies have established maximum exposure limits based on the “Linear non-Threshold” (LNT) model, that, in summary, predicts the linear increase in harmful effects with no safe level, with increasing levels of radiation. While the high-dose region of this model has been proven correct, its validity at low doses, particularly near background values, has been challenged. Recent experiments have shown that cells grown under chronic and/or acute low doses of radiation exhibit growth and fitness traits different from cells grown at control radiation levels, which suggest a radioadaptive response effect. The experiment uses bacteria, male mosquitos, and nematodes as subjects [12].

At the time of the incidents, the LBRE was not active. Testing conducted over the summer of 2013 was complete and work planning and control documentation was approved to allow investigators to move from using bacteria to larger organisms, such as mosquitos and nematodes. At present, power is off to the underground trailer that houses the experiment. Once power is restored to the northern area of WIPP, work control packages will be revised by TCO and LBRE staff to reflect current conditions and the experiments will be revived.

The Segmented Enriched Germanium Assembly / Multiple Element Germanium Array (SEGA/MEGA) Experiment

Since approximately 2004, the SEGA/MEGA experiments have been operating at the western end of the S-90 drift in the Room-Q alcove. Figure 3 shows this location in relation to the WIPP underground and the other science experiments. Experimental equipment is housed within connex buildings that provide high-efficiency particulate air filter systems. The basic element of the experiment is a high purity Germanium detector inside a thin copper inner liner, encased in lead bricks for shielding. The apparatus uses about ten liters of liquid nitrogen to cool the detector during normal operation. Approximately once a week, the liquid nitrogen tanks outside the connex were replaced by bringing new cylinders underground and transporting them with a forklift to the test location. Preceding the incidents at WIPP, the experiment was being used to optimize shielding arrangement to improve detector sensitivity and as a counter for various materials such as those that had been exposed to high energy at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory [13].

Because SEGA/MEGA is located upwind of the fire event, the alcove remained relatively clean of smoke and soot during the incident, unlike the other experiments in the northern area of WIPP. The investigators had concluded a series of counts on samples of Au from NIF in October 2013. They had conducted additional cleaning inside the clean room, began a background run of the detector, and calibrated the oxygen monitor in the building. Therefore, no experiments were in progress at the time of the fire.

Like the experiments in the northern area of WIPP, power is presently off to the Room-Q alcove. Once power is restored to this area of WIPP, the TCO will revise work control packages will revise to reflect current underground conditions and the experiments will be revived. Plans to use large fans in the S-90 drift to augment the underground ventilation by pulling more air down the air intake shaft may require several significant modifications to the air pathways and associated access around this experiment. The TCO is currently working with the WIPP contractor and CBFO to conduct appropriate planning to meet the test objectives for SEGA/MEGA and to address this important underground modification to ventilation.

The Dark Matter Time Projection Chamber (DMTPC) Experiment

The DMTPC is an experiment for direct detection of weakly interacting massive particles, one of the most favored candidates for dark matter, using a low-pressure time projection chamber located within a connex trailer in the northern experimental area of WIPP. The collaboration includes physicists from the Massachusetts Institute of Technology (MIT), Boston University (BU), and Brandeis University. Several prototype detectors have been built and tested in laboratories at MIT and BU. The group took its first data in an underground laboratory at the WIPP in Fall, 2010 [14]. The experiment is located in the northern experimental area, E-300/N-1400.

At the time of the incidents, the DMTPC was being remotely monitored and collecting data. The power outage on September 12 shut down all computers and monitoring equipment. The system is currently disabled and future entries to the area once power is restored will reinstate the experiment to operation. Work control packages will be revised by TCO and DMTPC staff to reflect current conditions and the experiments will be revived once power is restored to the area.

The next goal of the experiment investigators is to complete the design and construction of a next generation dark matter detector that replaces the currently-running version. The currently-running dark matter detector has a detector volume of about 50 liters, whereas the next generation detector is expected to have a volume of up to 4,000 liters, which is a factor of 80 larger comparatively. However, the actual technical procedures for operation of the detectors should be relatively the same. Since the new detector would be very large and heavy, the initial establishment and introduction of such detector into the WIPP underground will require careful planning by the TCO, the navigators and NWP operations.

Large-Scale Underground Thermal Testing

An area of ongoing research at WIPP is a planned test of bedded salt as a host for heat generating radioactive materials. There is a continued need for research into the potential performance of a repository for heat-generating waste in bedded salt and a need to better understand the integrated response of the salt at the field scale. In particular, it will be important to investigate the evolution of the small but non-negligible quantities of water within the salt as the heat from radioactive decay diffuses into the surrounding geologic medium [1][15].

The concept calls for a set of five heaters in each of two test drifts. The drifts would be configured identically except for the heat loads, which would be approximately 250W each in one test drift, and in the range of 750 to 1500W in the other drift. This configuration would enable study of large-scale behavior under both sub-boiling conditions and above-boiling conditions. The emphasis is on confirmation of expected behavior and validation of numerical models under both conduction-dominated and perhaps coupled thermal-hydrologic-chemical conditions. Standard measurements of temperature and drift closure would be made, along with an extensive set of measurements aimed at determining the fate and transport of mobilized water from inclusions, intergranular space, and hydrous minerals [2].

Associated with the thermal testing studies, at the time of the incidents, evaporation measurements were being taken in the north experimental area using pans of run-of-mine salt and beakers of brine, large samples of salt in the form of slabs were being excavated, and a study to examine the compaction of run-of-mine salt in a drift was being observed.

Planning for a field-scale heater test continues in fiscal year 2015 under the DOE Used Fuel Disposition campaign, and over 2000 meters of mining for the test bed in the underground has been completed. In addition, a full-scale prototype heater canister was designed and fabricated in fiscal year 2014 and is currently being tested in a surface facility in Carlsbad. All underground activities associated with the thermal testing program have been put on hold due to the underground incidents and fiscal year budget allocations. Although all mining, with the exception of the actual two test drifts, has been completed, mining to provide space for other tests associated with the URL [3] were halted at the time of the incidents. Ground support, electrical system procurement and installation, the development of the data collection and core storage alcoves, and installation of the URL infrastructure (including lights, communication, internet service) have been halted. Furthermore, the evaporation measurements were altered due to the heavy soot in the north area and the later power loss, and data collection on the salt compaction studies and sample collection activities were discontinued. Dependent upon the WIPP recovery efforts, resource availability, and progress of test planning for the thermal test, these underground activities are expected to resume in the future. As underground entries are becoming more routine to the northern area of WIPP, stored boxes of core are being removed from the underground for use in laboratory studies.

CONCLUSIONS

The activities and resources necessary for the recovery of the WIPP underground operations, and return to operability of the underground science program, are identified, scheduled and are being implemented. Every stage of recovery is supported by rigorous regulatory compliance by each performing organization (the TCO, NWP operations, principal investigator staff) and robust upgrades to nuclear safety, fire protection, radiological controls, emergency management, work control, scheduling, and associated documentation, procedures, and training.

As such, underground test coordination is an essential component of the safe and efficient implementation of testing operations in a working underground research laboratory, but becomes considerably more significant when dealing with multi-organizational field-scale test programs in a host facility undergoing a recovery with changing work control and conduct of operations processes. The TCO, under the framework and direction of the IPT charter, continues to refine the tailored work control systems to specifically address upgraded WIPP processes in balance with the unique requirements for research and development oriented workscope. As such, the TCO represents and advocates for the interests of the science community in the underground while helping to ensure that science operations do not impact the operations or recovery of WIPP. Therefore, it is essential to have a test coordination organization on-site and dedicated to the unique needs of a testing organization including work planning, training, general underground support, underground escort, and daily scheduling of the test activities with WIPP operations and recovery efforts.

Each of the science programs in progress at the time of the February 2014 incidents have their own unique impacts associated with the accumulation of soot, movement of the salt floor, loss of power, loss of access to the facility, or all four. Each program, therefore, will have their own unique plans for recovery in concert with WIPP's recovery plans, and all are affected by the impacts of new underground processes and procedures that are being imposed on underground work activities as a result. However, the TCO is supporting these experimental programs through test planning and developing appropriate work control documentation in accordance with their priority and the ability of the WIPP to support their individual needs. Each program is expected to fully recover from the incidents and the CBFO remains committed to recovering and standing-up the science programs described above in concert with the recovery of WIPP waste operations.

REFERENCES

1. Robinson, B.A., D. Weaver, P. Stauffer, R. Nelson, and N. Buschman. 2014. *The Salt Defense Disposal Investigations (SDDI): Current Status and Future Plans - 14486.* Waste Management Conference 2045, Phoenix, AZ, March 2-6, 2014.

2. *Draft Report*: *Test Plan for Phased Large-Scale Thermal Testing.* LA-UR-14-27937. Los Alamos, NM: Los Alamos National Laboratory. October, 2014.

3. *Proceedings of 4th US/German Workshop*. FCRD-UFD-2014-000335. Albuquerque, NM: Sandia National Laboratories. December, 2013.

4. DOE 2013a. *Science and Testing Activities in the WIPP Underground – Integrated Project Team Charter.* DOE/CBFO-13-3515. Carlsbad, NM: U.S. Department of Energy Carlsbad Field Office. November 2013.

5. DOE 2014a. *Accident Investigation Report – Underground Salt Haul Truck Fire at the Waste Isolation Pilot Plan February 5, 2014.* U.S. Department of Energy Office of Environmental Management. March 2014.

6. DOE 2014b. *Waste Isolation Pilot Plant Recovery Plan, Revision 0.* Carlsbad, NM: U.S. Department of Energy Carlsbad Field Office. September 30, 2014.

7. DOE 2014c. *Accident Investigation Report – Phase 1 – Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014*. U.S. Department of Energy Office of Environmental Management. April 2014.

8. Nelson, R.A., R. Patterson, and A. Van Luik. 2014. *The February 2014 Accidents at WIPP (What Happened and What We Know About Why – 14024).* Waste Management Conference 2015, Phoenix, AZ, March 15-19, 2015.

9. LANL-CO. *Testing Work Authorization and Control*. SDI-SP-001, Revision 1. Carlsbad, NM: Los Alamos National Laboratory – Carlsbad Operations Office. October 2014.

10. DOE 2012. *A Conceptual Plan for Salt Defense Disposal Investigations for the Disposal of DOE-EM Managed Wastes.* DOE/CBFO-12-3485. Carlsbad, NM: U.S. Department of Energy Carlsbad Field Office. June 2012.

11. *EXO*-200, *Enriched Xenon Observatory*. (https://www project.slac.stanford.edu/exo/about.html)

12. *Low Background Radiation Experiment.* (http://www.wipp.energy.gov/science/Biology/Biology2.html)

13. *SEGA-MEGA Experiment*. (http://www.wipp.energy.gov/science/dbdecay/SEGAandMEGAdescription.pdf)

14. *Dark Matter Time Projection Chamber*. (http://en.wikipedia.org/wiki/Dark_Matter_Time_Projection_Chamber)

15. DOE 2012. *A Conceptual Plan for Salt Defense Disposal Investigations for the Disposal of DOE-EM Managed Wastes.* DOE/CBFO-12-3485. Carlsbad, NM: U.S. Department of Energy Carlsbad Field Office. June 2012.

ACKNOWLEDGEMENTS

This work was performed through the Los Alamos National Laboratory Repository Science and Operations Program under the auspices of the U.S. Department of Energy, Carlsbad Field Office. This paper has been assigned the number LA-UR-14-28357 by the Los Alamos National Laboratory *Review and Approval System for Scientific and Technical Information* and is available for public release.