Post-Closure Challenges of U.S. Department of Energy Sites in Desert Environments of the Southwestern United States - 12095

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ABSTRACT

U.S. Department of Energy (DOE) sites located in harsh desert environments of the Four Corners region of the southwestern United States require diligence and continual maintenance to ensure the remediation systems function as designed to protect human health and the environment. The geology and climate of this area create issues that are unique to these sites. Geologic formations contain naturally occurring constituents that are often the same as the residual contaminants remaining from historical milling activities at the sites. Although annual precipitation is low, when precipitation events occur they can be of extreme intensity, resulting in erosion and flooding that can quickly destroy infrastructure and rapidly change site conditions. Winds can cause sand storms and sand mounding that effect site features. These challenging environmental conditions, along with the remote locations of the sites, require active management beyond what was originally envisioned for uranium disposal sites to address concerns in a safe and cost-effective manner.

REGULATORY SETTING

DOE established the Office of Legacy Management (LM) in December of 2003. At DOE sites where environmental restoration is complete or remedies are in place, LM is responsible for long-term surveillance and maintenance (LTSM), records management, work force restructuring and benefits, property management, and site reuse.

Of the various sites where LM has post-closure responsibilities, this paper focuses on the following sites located in the southwestern United States (U.S.): Bluewater, New Mexico; L-Bar, New Mexico; Monument Valley, Arizona; and Shiprock, New Mexico (Figure 1). These sites are regulated under the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978.
The uranium mill tailings and contaminated soils at the Shiprock and Monument Valley sites were cleaned up under Title I of UMTRCA, which applies to sites that did not have an active U.S. Nuclear Regulatory Commission (NRC) license when UMTRCA was enacted. The radioactive materials were encapsulated in NRC-approved disposal cells. The Shiprock and Monument Valley sites received general license approval from NRC in 1996 and 1997, respectively. The groundwater at these sites is being remediated in accordance with standards promulgated by the U.S. Environmental Protection Agency in Title 40, *Code of Federal Regulations,* and Part 192.

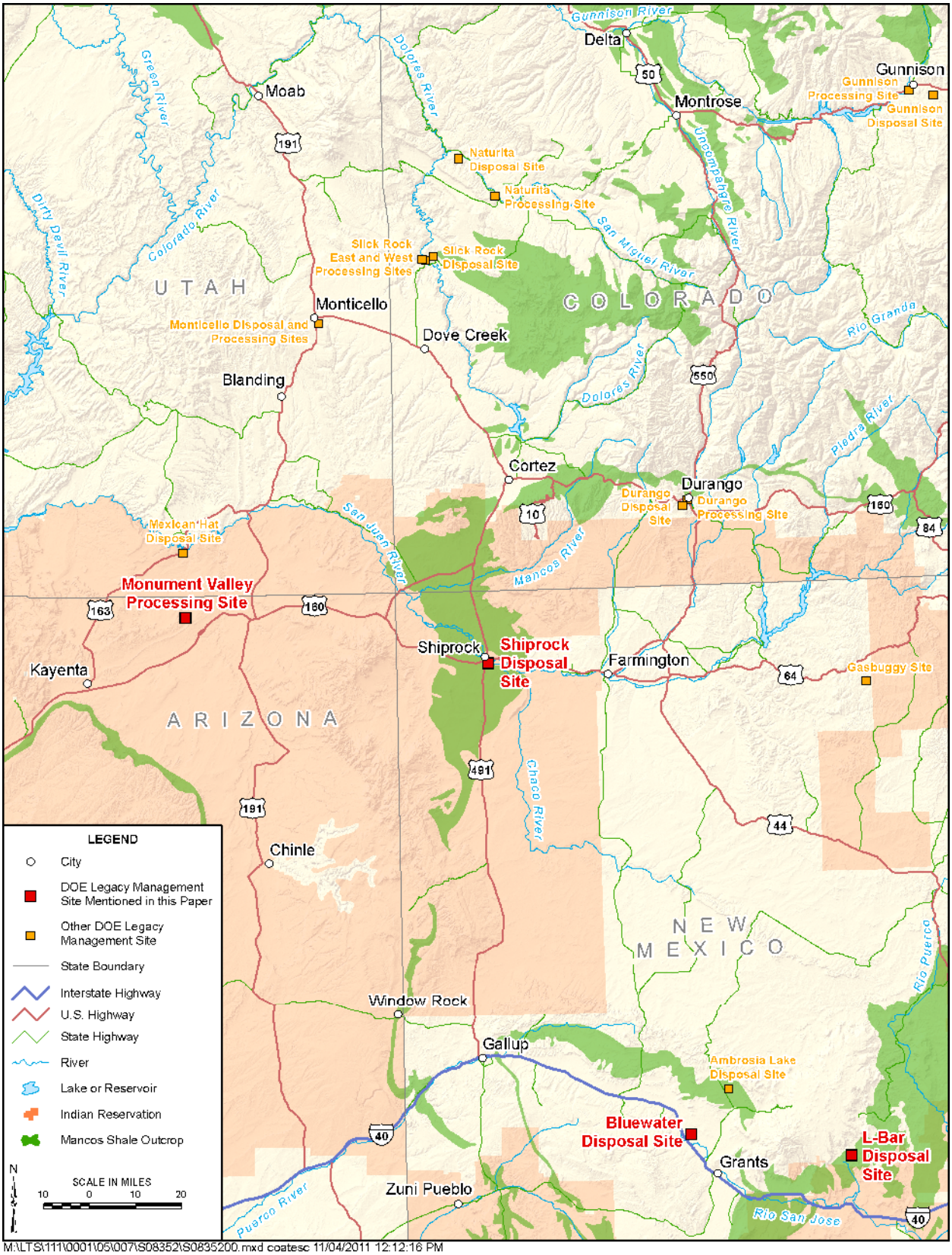

Figure 1. The Four Corners region and LM sites.

The Bluewater and L-Bar sites are under the jurisdiction of Title II of UMTRCA, which applies to uranium mill sites that were under active NRC licenses when UMTRCA was enacted. The Bluewater and L-Bar sites were included under NRC's general license and transferred to DOE in 1997 and 2004, respectively, for LTSM when the NRC approve the license and closure of the site.

OVERVIEW OF CHALLENGES

Many of the challenges DOE faces in protecting human health and the environment at LM sites in the southwest U.S. are directly related to environmental conditions in the region. Although by definition annual precipitation is low in the desert, when precipitation events occur they can be of extreme intensity, resulting in erosion and flooding that can quickly destroy infrastructure and rapidly change site conditions. Rainfall events in the desert are often short duration, high magnitude events, which result in significant runoff. Desert soils cannot absorb the high flow, resulting in erosion. Droughts add to the problem because vegetation cover is lost, meaning there is little to stop the erosive power of rain. A positive feedback loop can be established where ongoing drought results in loss of vegetation which means more runoff that causes more erosion that washes away soil.

At these remote, unmanned sites, management requirements and remediation costs can exceed planning estimates and costs of more complex sites that have on-site staff. Active planning to mitigate infrastructure damage, meet remediation goals, and ensure worker safety can exceed management requirements at similar sites elsewhere. Site infrastructure, such as buried utilities and roads, can be destroyed by sudden storms that produce large volumes of surface flow that result in significant erosion damage. Even robust engineering designs that have been implemented to mitigate further damage have been ineffective on several occasions.

The costs to mobilize subcontractors to these remote locations is often significant, and the costs often escalate when work and travel is halted by a need to leave the site ahead of storms. All work at these remote locations, which can be 32 to 48 km (20 to 30 miles) from the nearest paved road, must be carefully planned with consideration of communication and access to emergency services (which can be hours away). Extreme weather conditions often require work stoppages for safety reasons resulting in schedule delays.

The goal of remediation at many of these sites is often centered on the cleanup of groundwater, which is a scarce resource that holds significant value in the region. Thus, minimizing delays and impacts to remediation is a high concern. At unmanned sites, changed site conditions and damaged infrastructure might not be discovered in time to minimize impacts. The implementation of telemetry for monitoring has helped over the past several years, yet some have no utilities or communication infrastructure because of their isolated locations.

SITE DESCRIPTIONS

Bluewater, New Mexico

The Bluewater Disposal Site is in Cibola County in west-central New Mexico. The site comprises 1,335 hectares (3,300 acres). About one-third of the site (the southern and western parts) is covered by basalt, and much of the remainder of the site is covered with fine-grained material deposited by wind and water. The region around the disposal site is sparsely

populated, and the main land use near the site is grazing. The original carbonate-leach mill was constructed at the site in 1953. Mill decommissioning began in 1989, and site reclamation began in 1991. By 1995, all mill tailings, contaminated soils, demolished mill structures, and contaminated vicinity-property materials were encapsulated in six on-site disposal areas.

L-Bar, New Mexico

The L-Bar Disposal Site is in Cibola County approximately 75 km (47 miles) west of Albuquerque, New Mexico. The site consists of a 40 hectare (100 acre) disposal cell located on a 299 hectare (740 acre) parcel. The tailings impoundment is situated geologically in the San Juan Basin with Mesozoic and Paleozoic sedimentary rocks overlying Precambrian age material. Seepage of tailings fluid has contaminated the uppermost aquifer below the disposal cell with chloride, nitrate, selenium, sulfate, and uranium.

Shiprock, New Mexico

The Shiprock Disposal Site is the location of a former uranium and vanadium ore-processing facility within the Navajo Nation in the northwest corner of New Mexico near the town of Shiprock, approximately 45 km (28 miles) west of Farmington. The disposal cell and adjacent former mill site area sit on a terrace above the San Juan River floodplain. The horizontal distance from the disposal cell to the San Juan River is about 183 m (600 feet). Past milling operations have left contaminants in the terrace groundwater system and in the floodplain alluvial aquifer. Contaminated groundwater from the terrace has infiltrated the upper meter or more of the underlying weathered Mancos Shale bedrock and has migrated into the alluvial aquifer on the floodplain.

Groundwater at the Shiprock site is being remediated by an extensive pump and evaporate system aimed at contaminant removal and dewatering. Phytoremediation for plume control is being studied at this site to see if it would be a viable addition to the pump and evaporation treatment system.

Monument Valley, Arizona

The Monument Valley processing site is located on the Navajo Nation in northeastern Arizona, about 24 km (15 miles) south of Mexican Hat, Utah. The site is isolated and accessible only via unmaintained dirt roads. Approximately 2 million cubic meters (540 million gallons) of water are contaminated with nitrate in the alluvial aquifer; the plume has migrated more than 1,377 m (4,500 feet) north of the former mill site. Mill tailings and other contaminated material from the Monument Valley site were encapsulated in the disposal cell at the Mexican Hat, Utah, Disposal Site about 16 km (10 miles) north of the Monument Valley site.

The Monument Valley site groundwater is being remediated as part of a pilot study that uses phytoremediation. The phytoremediation system consists of multiple irrigated plots of native phreatophytes that use nitrate as a plant nutrient. (Nitrates are a primary component in fertilizers.)

POST-CLOSURE CHALLENGES

Erosion

The Shiprock and L-Bar sites have both had major erosion problems from large storm events. Structures installed to manage erosion have been washed out by storms at both sites.
The L-Bar site has erosion occurring at a rapid rate at two principal locations that could threaten the integrity of the disposal cell and the site access road. Four structures, designed for a 25-year/24-hour storm (6.6 cm [2.6 inches] of rainfall), were constructed in fall 2009 to control runoff and reduce erosion. However, severe storms during August 2011 resulted in damage to and significant erosion around the structures (Figure 2).

Figure 2. Storm damage to erosion control structure at L-Bar site.

At the Shiprock site, components of the remediation system in washes were threatened and so were protected with rock armor and gabion walls. These engineered structures designed to minimize erosion were destroyed during a single storm event within a few months after installation.

In addition to the well-understood power of water to produce significant erosion, significant damage can occur at these sites from frequent high winds. Portions of the Monument Valley site have had as much as 1 m (2 to 3 feet) of surface material scoured away over areas as large as 4 to 6 hectares (10 to 15 acres) from high winds lasting only a few days, while other areas of the site have had so much deposited material that fences 1.2 m (4 feet) high were buried. The

protective concrete pad on the monitoring well shown in Figure 3 was originally at ground level, and the well's stability and integrity is now threatened due to wind erosion. Likewise, the wire fence shown in the Figure 3 was originally constructed at ground level. This large gap that wind erosion created beneath the fence allowed open range livestock to access the site and graze on plants being used for phytoremediation.

Figure 3. Wind erosion at Monument Valley.

The Bluewater site has problems with mounding sand allowing cattle access over the site fences. After several efforts to remove accumulated sand along portions of the site perimeter fence, it was determined that tumbleweeds (dried Russian thistle and kochia) catching on the bottom strands of the barbed-wire fence were acting as a sand fence, causing windblown sand to drop along the fence line. The bottom stands of barbed wire were removed and replaced with one strand of barbless wire, which significantly reduced the accumulation of weeds and the corresponding deposition of sand.

Remote Locations

Monument Valley is located in a sparely inhabited area of the Navajo Nation. Access to the sites is by unmaintained dirt roads. Monitoring, site inspections, and repairs often require large equipment to repair access roads in order to get personnel and equipment to the site (Figure 4). On occasion, storm events following initial access-road repairs have resulted in vehicles and equipment being left at the site until the most recent damage can be repaired.

The communication and emergency planning for work at these remote locations needs to ensure that site workers and visitors are prepared for unexpected and extreme weather and environmental conditions, as there must be contingency planning for equipment failures and loss of communication.

Figure 4. Road leading to the Monument Valley site.

Over the past 6 years, the LM program has installed telemetry and remote sensing equipment at some remote sites as a tool to more quickly assess conditions at remote sites and to reduce travel requirements. The System Operation and Analysis at Remote Sites (SOARS) telemetry program has been most successful at those remote sites where active remediation is ongoing. SOARS is a system of environmental monitoring instruments that are linked by telemetry for data transmission to the LM office in Grand Junction, Colorado. The data can be viewed using web-based software that displays real-time data. Besides providing access to site and remediation system conditions, SOARS also allows operators to remotely control remediation system functions such as pump controls and flow rates. The current SOARS instrumentation used by LM can monitor in-line pressure for pump and treatment system controls, groundwater elevations, weather conditions, water conductivity, temperature, turbidity, solar radiation, and soil/water content. In addition, webcams have been deployed at some sites and transmit through SOARS.

Natural Contamination

Water resources are an important and valuable commodity in the southwest U.S., particularly within the Navajo Nation. This is exemplified at the Shiprock site, where an artesian well with naturally high levels of sulfate (3,000 mg/L) is allowed to flow in the middle of the community as a public resource. Despite regulators' preference that the well be capped, water from this well is made available because of the public concern that access to the resource might be restricted.

In addition to sulfate, elevated concentrations of nitrate, selenium, and uranium are often found in naturally occurring concentrations at sites in the region. Southwestern deserts are known to naturally accumulate nitrate and sulfate in soil horizons and groundwater, and the Mancos Shale that underlies much of the region has been demonstrated as a source of naturally occurring nitrate, selenium, and uranium at levels that often exceed regulatory standards [1]. Natural sources may be contributing to concentrations in aquifers at several LM sites, including Shiprock and Monument Valley [2]. Consequently, differentiating between natural concentrations and contaminants from milling and processing is often a challenge when developing a compliance strategy at these sites.

CONCLUSION

The unique environment of the Four Corners region creates many challenges to the LTSM of LM sites in southwestern United States. The remediation efforts and approaches to infrastructure have to be specifically structured to work in this environment. Often, the systems and structures have to be modified based on lessons learned on how to best adapt to these difficult conditions and remote locations. These sites require continual maintenance and additional efforts compared to many other LM sites.

REFERENCES

1. DOE (U.S. Department of Energy), 2011. *Natural Contamination from the Mancos Shale* Environmental Sciences Laboratory, April.

2. DOE (U.S. Department of Energy), 2006. *Soil and Ground Water Phytoremediation Pilot Studies at Monument Valley, Arizona 2005 Status Report,* July.