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THE LEGACY URANIUM MINING AND MILLING CLEANUP PLAN:

EVALUATION OF THE EPA FIVE-YEAR PLAN,

GRANTS MINING DISTRICT, NEW MEXICO

By

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ABSTRACT

Uranium mining and milling in northwestern New Mexico (NM) impacted soils, stream sediments, surface water, and ground water with elevated levels of radioactivity and toxic heavy metals. Uranium and its radioactive decay products such as radium and radon gas present a significant public health and safety hazard and environmental health risk. The exposure of people and the environment to heavy metals and radionuclides in soil, air, and water in the vicinity of legacy uranium operations in the Grants District requires mitigation through the systematic assessment and cleanup of materials and sites bearing these hazardous contaminants. In August 2010 EPA released the *Five-Year Plan Grants Mining District, New Mexico* to assess and cleanup hazards from legacy uranium in northwestern NM. An evaluation of the activities in the first five years (2010-2014) of such a large-scale project was performed to determine if there has been measurable progress toward major goals and specific tasks in the Plan. The Six Objectives of the Plan address the following areas: 1. ground water; 2. mines; 3. mills; 4. structures; 5. Jackpile Mine, and 6. biomonitoring. The

Plan accomplishments and progress during 2010-2014 toward completion of these six Objectives indicates that *Jackpile Mine and Biomonitoring* (Objectives 5 and 6, respectively) were achieved. Objectives 3 and 4 (*mill sites and residential structures,* respectively) show accomplishments and continuing work. Objectives relating to ground water and mine cleanup (Objective 1 and 2) show some progress but these two objectives were not fully achieved. Constraints and complexities related to regulatory practices, uncertainties, financial burden, and health impacts were identified as hindrance to full completion of the Six Objectives. Recommendations to support future work include development of an implementation plan for ground water, full enforcement of state ground water protection regulations, enhanced public involvement, and better collaboration among five-year plan agencies.

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Chapter 1: Introduction

The northwest part of New Mexico (NM) in an area known as the Grants Mineral Belt (GMB) or Grants Mining District ("Grants District") is home to the second largest uranium reserves in the United States (U.S. Energy Information Administration, 2010). Uranium mining and milling in the GMB began in the early 1950s and it produced uranium concentrates that were sold to the Atomic Energy Commission (AEC) in order to supply uranium for the U.S. nuclear weapons program and the commercial nuclear power industry (Albrethsen & McGinley, 1982). Uranium mining and milling in NM impacted soils, stream sediments, surface water, and ground water (Eadie & Kaufman, 1977; Brierley & Brierley, 1981; Gallaher & Goad, 1981; Gallaher & Cary, 1986). Early on the hazards and health effects from uranium mining and milling subjected workers, their families, nearby residents, and the environment to elevated levels of radioactivity and toxic heavy metals (Ringholz, 2002; Brugge, Benally, & Yazzie-Lewis, 2006). Figure 1 presents a map of the Grants Mining District.

Uranium and it's radioactive decay products such as radium and radon gas present a significant public health and safety hazard and environmental health risk because these contaminants can poison tissues and cause cancer if ingested or inhaled (Environmental Protection Agency [EPA], 2008, Agency for Toxic Substances and Disease Registry, 2013). Uranium and radium will undergo radioactive decay for thousands of years presenting a unique and persistent long-term hazard for many generations (EPA, 2008a, & Department of Energy [DOE], 2014a).

Uranium mill tailings are a dense sand-water mixture enriched with heavy metals like arsenic, molybdenum, iron, and selenium along with leftover acid or alkaline solutions (EPA, 2008a). Tailings radioactive decay products require a properly engineered earthen cover and monitoring for 200 to 1,000 years to mitigate the radon gas hazard (40 CFR 192.02, 2015). Native ground water directly beneath a mill site and sometimes outside mill property boundaries is often rendered unsuitable for drinking and other uses if it becomes polluted with contaminants from tailings seepage (Robinson, 2004; NM Office of Natural Resource Trustee [ONRT], 2010; EPA, 2008a). The four mill sites in the Ambrosia Lake area: Bluewater Disposal; Homestake-Barrick; Rio Algom (formerly Kerr McGee and Quivira); and Phillips-United Nuclear Corporation (UNC) have contaminated ground water beneath and around the mill site with concentrated tailings seepage (DOE, 1990; NM ONRT, 2010; DOE, 2014b; & EPA, 2011a).

Improperly reclaimed or un-reclaimed legacy uranium mine sites in the Grants District present physical hazards like open shafts, adits, jagged metal debris, and uncovered piles of waste rock and ore that contain elevated levels of radioactivity and heavy metals (EPA, 2008a; & DOE, 2014b). Some heavy metals and radionuclides in piles of uranium waste rock on site and in nearby arroyos are episodically spread further down slope and out into the environment by wind as dust and in water as suspended sediment during precipitation runoff events. People, plants, and animals currently residing in the vicinity of former uranium mining and milling sites are potentially exposed to radioactive and heavy metals in the soil, air, and water (EPA, 2008a).

The NM Uranium Mining and Mill Tailings Task Force (UMMTTF) comprised of state legislators, managers, and experts identified three distinct concerns of contamination left behind from uranium operations: abandoned mines and mine waste; mill sites and mill tailings; and contamination of ground water (NM UMMTTF, 2009). Contaminated aquifers in NM have expanding plumes of contamination and health advisories have been issued (NM UMMTTF, 2009 & EPA, 2010). A limited biomonitoring study of volunteer residents in the GMB revealed elevated levels of uranium in their urine several times the national average (NM Department of Health [DOH], 2011). A Cibola County, NM resident and their livestock were temporarily relocated in 2011 as part of EPA's radiological assessment work in the GMB (EPA, 2013b). An EPA study of the human health risk from remediation activities at the Homestake mill site indicated there is a slight risk of cancer from radon above EPA's preferred risk range to some residential neighborhoods south of the site (EPA, 2013a). The exposure of people and the environment to heavy metals and radionuclides in soil, air, and water in the vicinity of legacy uranium operations in the Grants District requires mitigation through the systematic assessment and cleanup of materials and sites bearing these hazardous contaminants.

Some uranium mines in the Grants District were constructed in zones of high quality ground water that had to be pumped out of the "wet" mine and discharged to dry washes or stream channels on a constant basis to enable underground operations (Eadie & Kaufman, 1977; Gallaher, & Goad, 1981; Gallaher & Cary, 1986; & NM ONRT, 2010). Over a 30-year period, tens of billions of gallons of mine water containing numerous pounds of heavy metals were pumped out and discharged to the surface of the Ambrosia Lake area drainages and into the San Mateo Creek (SMC) basin (Gallaher, & Goad, 1981; Gallaher & Cary, 1986). Beginning in the late 1970s, the discharged mine water required a federal permit under the Clean Water Act and treatment to remove contamination, but prior to then many uranium mines dewatered for many years with little waste water treatment or monitoring (Eadie, & Kaufman, 1977; Gallaher & Cary, 1986). Little is known about the environmental conditions and any potential future use hazards for impacted ground water quality relative to the large volume of legacy uranium mine discharge water that flowed down the SMC channel for years and possibly infiltrated the deeper ground water system (EPA, 2010; New Mexico Environment Department [NMED], 2010).

In 2009 the New Mexico Environment Department (NMED) issued an advisory to private well owners in the SMC Basin that ground water my contain contaminants from naturally occurring ore and processes from past uranium mining (NMED, 2009). This public advisory was part of a long-term effort to assess and cleanup the legacy uranium impacts in the SMC Basin that includes the Ambrosia Lake area mines and mills. The U.S. Environmental Protection Agency (EPA) collaborated with other federal land management agencies, the state of NM, the public and tribal nations to develop the 2010 EPA Five-Year Plan to assess and cleanup the legacy uranium impacts in Grants Mining District. Some parts of a District cleanup plan were already in place with the Department of Energy (DOE) responsible for the long-term management of the Bluewater and UNC-Phillips disposal sites; the Homestake site working under federal and state regulatory supervision to complete remediation; and the Rio Algom (formerly Kerr McGee) mill site commencing the final stages of decommissioning and remediation under NRC supervision (EPA, 2010). All that remained to develop an overall cleanup plan was to include all the legacy uranium mine sites and the impacted surface and ground water areas between and down gradient of mill sites and wet mines. In August 2010 EPA released the *Five-Year Plan Grants Mining District, New Mexico* to assess and cleanup hazards from legacy uranium (EPA, 2010). Figure 2 presents a map of the legacy uranium mills and mines in the Ambrosia Lake area.

In 2010 a comprehensive, coordinated program to assess and mitigate over 90 legacy uranium mine sites in the GMB was developed and implemented (EPA, 2010). The assessment and cleanup of hazardous legacy uranium sites is a very challenging task because of the complex, enduring nature of radioactive materials, and the significant time and funding required for such a large project (EPA, 2008a, 2010 & DOE, 2014a). Well-developed strategies and plans are important components in a multi-agency program to cleanup the legacy uranium impacts in the GMB. An evaluation of the activities in the first five years (2010-2014) of such a large-scale project is prudent in order to determine if there has been measurable progress toward major goals and specific tasks. The evaluation also provides some cost estimates to help gauge the funding levels required to assess and complete legacy cleanup. Recommendations are provided to optimize plan strategies, resources, and execution during future phases of work.

Chapter 2: Legacy Uranium Cleanup Plan

In August 2007, the Environmental Protection Agency (EPA) Region 9 (San Francisco, CA) released a report entitled, "*Abandoned Uranium Mines and the Navajo Nation-Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data*" (EPA, 2007). The report documented, mapped, described, and ranked the hundreds of abandoned uranium mine (AUM) sites on the Navajo Nation for health risks and prioritization for further investigations and/or cleanup. Concurrently, articles in the Los Angeles Times described the impact of uranium mine and mill sites on the health of the Navajo People and their culture, along with the multiple failure of the federal government multiple times to address the situation (Pasternak, 2006). The article caught the attention of Representative Henry Waxman (California), Chairman of the House Committee on Oversight and Government Reform. Waxman convened an investigation and requested a presentation from representatives of the Navajo Nation on the condition of AUMs on their reservation lands in Arizona, New Mexico, and Utah (Reynolds, 2007). Waxman introduced the investigation by describing the situation as, "a forty year history of bipartisan failure and a modern American tragedy." He demanded a plan of action from the five federal agencies responsible for the tragedy: the EPA, the DOE, the Bureau of Indian Affairs (BIA), the Indian Health Service (IHS), and the Nuclear Regulatory Commission (NRC). Shortly thereafter a plan entitled, "*Health and Environmental Impacts of Uranium Contamination in the Navajo Nation-Five Year Plan*" was developed (EPA, 2008b & Government Accountability Office, 2014).

In 2009 after hearing similar and valid concerns from NM residents in the Grants area, the NMED asked EPA Region 6 (Dallas, TX) to develop a plan to help assess and cleanup legacy impacts of uranium mining and milling in NM (EPA, 2010). The EPA released a 52-page document in August 2010 entitled, "*Assessment of Health and Environmental Impacts of Uranium Mining and Milling, Five-Year Plan, Grants Mining District, New Mexico*." The goal of the EPA Region 6 Five-Year Plan (5YPlan) is, "*to promote and advance the work needed to help restore and preserve the natural and cultural resources in the Grants Mining District and to ensure protection of human health for future generations*" (EPA, 2010, p.5). The 5YPlan includes six major objectives, "*designed to comprehensively address legacy contamination of water resources, sediment and structures, and ensure urgent issues are acknowledged and mitigated*." The six major objectives of the 5YPlan address the following issues:

1. **Ground Water**
2. **Mines**
3. **Mills**
4. **Structures**
5. **Jackpile Mine**
6. **Biomonitoring**

Table 1 presents a summary of the six objectives, responsible agencies/programs, and the Action Plan Tasks prescribed for each major objective.

EPA and NMED collaborated with other federal, tribal, and state agencies that have regulatory jurisdiction and the responsibility for protecting human health and the environment in development of an assessment/cleanup strategy for the six objectives. The 5YPlan calls on each agency to implement appropriate laws, regulations, and policies within their jurisdiction to accomplish cross-organizational activities that help identify, assess, cleanup, and monitor uranium legacy sites and their impacts (EPA, 2010, p. 3). The 5YPlan requires that agencies commit to the accomplishment of these objectives from 2010 to 2014.

Section 3 of the 5YPlan (p. 30) presents an Implementation Timeline for each major objective and short statements of work.

EPA has provided factsheets and/or site activities updates on the 5YPlan on an annual/semi-annual basis since 2010 (EPA, 2012c, 2013b, 2014a, 2014b). EPA provided the "*Updated March 2014*" Five Year Plan detailing the major accomplishments during 2010-2014) and next steps for each of the six major objectives. They are summarized below:

1- **Ground Water**. *Accomplishments*: "EPA and NMED collected/evaluated ground water data and planned for collection of new data in 2014."

   Next Steps: "continue to refine the ground water investigation plan; identify locations for new monitoring wells and construct and sample monitoring wells in 2014; identify private wells for sampling in 2014; and continue regional mapping of contamination in shallow and bedrock aquifers in the San Mateo Creek drainage basin."

2- **Mines**: *Accomplishments*: "completed field investigations of documented hazardous releases at four Ambrosia Lake mines; Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Section 104(e) letters were mailed to five potentially responsible parties (PRPs) in 2011; enforced a required site investigation at the Johnny M Mine according to a Removal Action Administrative Order on Consent; completed site evaluations at Barbara J complex of mines in Poison Canyon; completed environmental assessment of Spencer Mine; reviewed proposal for reclamation of Rio Puerco Mine; and evaluated need for ground water abatement or reclamation at mines through implementation of NM mining and ground water discharge permitting programs."

   Next Steps: "Hecla shall complete engineering evaluation and cost analysis of remedial options at Johnny M Mine; Bureau of Land Management (BLM) shall design a removal action to close shafts and bore holes on the Barbara J complex of mines and cap highest radiation levels in soil by end of 2014; perform construction work in 2015; BLM shall prepare a design reclamation plan to address the erosion issues at the Spencer Mine; U.S. Forest Service (USFS) shall complete engineering evaluations and cost analyses for closure/remediation of four mines located on USFS lands in 2014. BLM shall complete review of the reclamation plan for the Rio Puerco Mine; EPA or other regulatory agencies shall conduct emergency action at mine sites when warranted due to releases of hazardous substances to the environment or physical hazards; NM Energy Minerals, and Natural Resources Department (EMNRD) and NMED shall continue to evaluate need for ground water abatement actions or reclamation at mines through the implementation of New Mexico's mining and ground water discharge permitting programs."

3- **Mills**: *Accomplishments*: "DOE continued to monitor ground water quality in aquifers at the Bluewater site to delineate the extent of contamination including the installation of 10 new monitoring wells; EPA is preparing responses to comments received on the Draft Baseline Human Health Risk Assessment (HHRA) for the Homestake site; reviewed Corrective Action Program for the Homestake site; supported the renewal process for state of NM Discharge Permit-200 for the Homestake site."

   Next Steps: "DOE shall continue to conduct the ground water investigation at the Bluewater Mill site, including installation and sampling of additional monitoring wells, if warranted; EPA shall respond to public comments and complete final HHRA Report for Homestake Mill site; NRC shall complete revision of the ground water Corrective Action Program for the Homestake Mill site based on comments from federal and state agencies and the public; NMED shall respond to comments on DP-200 by Multicultural Alliance for a Safe Environment (MASE), Bluewater Valley Downstream Alliance (BVDA) and others."

4- **Structures**: *Accomplishments*: "assessed 891 structures/properties, 83 cleaned up, 45 targeted for cleanup; assessed properties/structures in Acoma Pueblo; installed one radon abatement system near Homestake; constructed a waste staging area for removal actions planned for 19 properties south of Homestake."

   Next Steps: Complete removal action cleanups at 19 residential properties in the Mormon Farms area; continue to assess properties/structures in Acoma Pueblo villages; continue to implement radon abatement at residences, as warranted; continue to clean up contaminated soil at residences, as needed; continue to clean up contaminated structures, as needed.

5- **Jackpile Mine**: *Accomplishments*: "The site was placed on the NPL (National Priority List) of Superfund Sites in December 2013." *Next Steps*: none specified.

6- **Public Health Surveillance**: *Accomplishments*: "New Mexico Department of Health (NMDOH) conducted public health surveillance for uranium exposure; NMDOH successfully added uranium exposure as a notifiable condition." *Next Steps*: none specified.

In November 2014 EPA released "*Site Activities Update*" summarizing the status of activities pertaining to the Grants Mining District and Homestake Superfund Site projects (EPA, 2014b). The 2014 Update refers to the Grants Mining District 5YPlan as, "*an umbrella project to cover a large area*." The 2014 Update briefly described activities pertaining to a ground water investigation in the San Mateo Creek (SMC) Basin focused on the nature and extent of contamination in the surface drainages and alluvium. At the request of local residents many private water wells in the SMC Basin are also being sampled by NMED (EPA, 2014b). Information from the "*sampling plan*" and laboratory results will be posted on the EPA Region 6, New Mexico website where Homestake information is also posted (http://www.epa.gov/region6/6sf/newmexico/). The status of the Homestake remediation efforts to date are under review by the EPA to determine if the compliance of those activities under NRC requirements meets EPA's Superfund requirements for protectiveness in order to support license termination. The 2014 Update indicates ground water investigation information will be posted on the web page and a proposed public meeting in spring 2015 will present and discuss sampling results.

Work to support *Next Steps* of 5YPlan Objectives by the State of New Mexico includes the development of strategies for assessment and cleanup of sources of sediment, surface, and ground water, and air contamination originating from mines (EPA, 2014b). In the annual summary report of water resource protection activities the State provides to EPA and the public under the Clean Water Act Section 303/305 requirements, the NMED Superfund Oversight Section is developing these strategies under work entitled, "*Significant Ground Water Issues, Assessment of Grants Mining District*."

Chapter 3: Purpose and Methodology

This thesis presents a limited evaluation of the 2010 EPA Five-Year Plan toward accomplishment of the Six Objectives during the 2010-2014 period. The thesis also identifies constraints and issues that will need to be addressed in the next five-year period of the 5YPlan. The 5YPlan contains objectives and strategies that were developed by EPA in collaboration with several other federal agencies, representatives of the New Mexico legislature, non-profit organizations, and the community (EPA, 2010). The objectives were designed generally to comprehensively address impacts from legacy uranium mining and milling and to prioritize issues for more immediate attention. The Plan identified Six Objectives: 1) Ground Water; 2) Mines; 3) Mills; 4) Structures; 5) Jackpile Mine; and 6) Biomonitoring. The Six Objectives were not prioritized in the 5YPlan, but instead are referenced in an “Implementation Plan Time Line” for years 2010-2014 which indicates when Action Plan Tasks were to be active and/or completed.

Accomplishments in the completion of the Six Objectives Action Plan Tasks over the 2010-2014 period were evaluated against three major criteria: Regulatory Legislation and Programs; Technical Factors and Considerations; and Financial Issues and Constraints. The evaluation used published information to determine the degree of completion for each of the Six Objectives. EPA updates on the status of activities and accomplishments under the 5YPlan and other agency documents produced during the 2010-2014 period were the primary sources of information for the evaluation of the Action Plan Tasks for each of the Six Objectives. Table 5 summarizes the status of the progress and completion of EPA 5YPlan Six Objectives and Action Plan Tasks. The EPA 5YPlan Six Major Objectives and Action Plan Tasks are summarized in Table 1.

The regulatory analysis was conducted to identify the current set of federal and state environmental statutes that are directly applicable to each 5YPlan Objective. The technical analysis was conducted in order to better define and understand the complexities, scope, and important factors in the technical work described and required for completion of each 5YPlan objective. A financial analysis was conducted to approximate the estimated cost amount or range of cost to complete work under each 5YPlan Objective. EPA updates on the status of activities and accomplishments under the 5YPlan and other agency documents produced during the 2010-2014 period were the primary sources for accomplishment information.

Chapter 4: Criteria for Legacy Uranium Mine Assessment and Cleanup

Environmental Laws and Regulation

This section focuses on the environmental regulations and programs that address impacts resulting from legacy uranium mining and milling operations in the Grants District through 2014. The 2010 EPA *Five-Year Plan* in *Appendix A* contains a table of federal and state regulations that apply to various aspects of the environment and the mining industry. In order to not repeat published information that is readily available regarding federal and state environmental regulations pertaining to uranium mining and milling operations, the first part of this literature review is focused on specific regulations. The second and third parts of the literature review address technical/financial information and factors related to uranium mine and mill site cleanup.

Federal environmental regulations. The earliest body of regulations pertaining to uranium materials and atomic energy development is found in the Atomic Energy Act (1946 & 1954: 42 United States Code, U.S.C., § 2011 et seq.). The AEA created the Atomic Energy Commission (AEC). The AEA did not include regulations for uranium mine operation, that responsibility was given to the State. The history of uranium mining and milling in the Grants District and Four Corners Area is a boom-bust cycle (Ringholz, 2002). The uranium mining industry expanded at a fast rate beginning in the late 1950s before most federal and state regulatory laws were legislated and implemented. Aside from the 1948 Federal Water Pollution Control Act, and the 1963 Clean Air Act, it wasn't until the 1970s that major, comprehensive federal environmental laws were passed to directly address the various sources and types of pollutants in the Nation's environment involving air, food, soil, and water sources. Table 2 presents a summary of the major federal laws, regulations, and guidance that pertain to impacts from uranium mining and milling operations.

Clean Water Act (CWA). Revisions to the 1948 Federal Water Pollution Control Act in 1972 became known as the "Clean Water Act" was the first federal law that provided a legal means to address and improve the water quality from uranium mine dewatering discharges in the Grants District. The Clean Water Act (CWA) requires that any facility discharging pollutants into "waters of the U.S." from a point source to obtain a permit issued by the EPA. The permit requires dischargers to demonstrate that it is using best practice control technology (BPT) or best available technology (BAT) to curb the pollution from the discharge. The CWA permit program is known as the National Pollution Discharge Elimination System or NPDES. The NM uranium industry challenged EPA's jurisdiction and was successful at avoiding NPDES permit compliance for several years (Townsend, 1978). The NM uranium industry also contended that the polluted water was not harming humans since no one was using the water (Townsend, 1978).

Solid and hazardous waste. Major federal environmental legislation developed in the 1970s and 1980s was directed at the management of solid, toxic, and coalmine wastes (see Table 2). Regulations for managing uranium waste as hazardous waste were deferred in 1978, as "Special Waste," because further study and assessment were required to determine their risk to human health and the environment (EPA, 2014c). Amendments to the Resource Conservation and Recovery Act (RCRA) in 1980 added sections that "exempted" Special Waste from regulation until further studies of risk could be performed (EPA, 2014c). On July 3, 1986 EPA published the Final Regulatory Determination for Extraction and Beneficiation of Waste that determined regulation of these Special Wastes including uranium mine waste under RCRA Subtitle C is not warranted and would continue to be excluded from the definition of hazardous waste (51 FR 24496). Exemption from RCRA Subtitle C, however, does not mean the waste is unregulated because it is subject to other state or federal regulatory requirements (Luther, 2013). Federal regulatory requirements that are potentially applicable to Special Waste include those established under the CWA and Safe Drinking Water Act (SDWA).

Uranium Mill Tailings Radiation Control Act (UMTRCA). This Act provides a program of assessment and remedial action at *inactive* uranium mill sites in order to stabilize and control radioactive mill tailings in a safe and environmentally sound manner to minimize radiation hazards to the public. It also regulates mill tailings or thorium ore processing at active mill operations after termination of such operations in order to stabilize and control tailings in a safe and environmentally sound manner that minimizes or eliminates radiation health hazards to the public (NRC, 2013). Title I the Act covers inactive mill sites that were licensed by the AEC and stopped operating before 1978 and Title II covers mill sites that were licensed by the NRC beginning in 1978. Generally, EPA is responsible for environmental health standards and compliance at an NRC licensed facility. NRC is responsible for regulating cleanup on and from the facility, and transfer of the license to DOE or state. The DOE or state is responsible for long-term perpetual care (EPA, 2013a & NRC, 2013).

Comprehensive Environmental Response Compensation and Liability Act (CERCLA). The Act, also known as “Superfund,” focuses on the cleanup of contamination resulting from the past release of hazardous substances excluding petroleum which primarily is covered under the Oil Pollution Act (EPA, 2012b). It provides broad federal authority to respond directly to releases or threatened releases of hazardous substances, pollutants, and contaminants including radionuclides that may endanger public health or the environment. It authorizes short-term, prompt responses/removals and long-term remedial actions like those found at National Priority List (NPL) sites. 1986 Superfund Amendments & Reauthorization Act provided important additions and changes in the program.

Bearden, et al. (2013, 67) succinctly describe the important policy of liability for cleanup under CERCLA:

> "*CERCLA established a broad liability scheme that holds both past and current owners and operators of contaminated facilities financially responsible for the costs of cleanup. If potentially responsible parties cannot be found or cannot pay for the cleanup, CERCLA authorizes the federal government to finance the cleanup to ensure the protection of human health and the environment. The broad liability scheme of CERCLA is intended to capture all parties that may have had some involvement in the actions that resulted in contamination of the environment, in order to minimize the burden of the costs of cleanup on the general taxpayer who had no involvement. This approach to liability is based on the principle that polluters should be required to pay for the environmental damage that they cause, often referred to as the "polluter pays principle*."

Even the federal government is liable as a potentially responsible party (PRP) under CERCLA since there are 129 federal facilities on the NPL, 103 of which are Department of Defense (DOD) sites (GAO, 2013). The federal government is also liable for hazards and environmental damage from an estimated 33,000 mines located on federal lands in 12 western states and Alaska (GAO, 2013). Section 104(c)(3) of CERCLA requires the state in which a non-federal NPL site is located to "share" 10% of the remedial action cost at that site, as a condition of obligating federal Superfund monies to finance those actions (Bearden et al., 2013). Early in the CERCLA Process a PRP search is conducted to establish evidence of liability and to send a CERCLA Section 104(e) letter requesting information about waste types and volumes at a site under investigation (EPA, 2009b).

Investigation and remediation of sites under CERCLA follow a phased approach of information gathering and evaluation to determine and document the level of risk posed by the site to humans and the environment. Figure 3 depicts a simplified illustration of the CERCLA-Superfund Process. As of December 2012, there were 3,400 sites that were eligible for listing on the NPL, and there were 1,311 sites on the NPL as of April 2013 (GAO, 2013).

The performance of CERCLA and the time and cost effectiveness of placing a site on the NPL for cleanup is controversial and complicated (Burnett, 1996). For example, Burnett (1996) and Stroup (2001) describe the history of Superfund as a failure of environmental regulation because the liability policy is unfair, the costs to cleanup sites are large; and the time it takes to bring the site to completion is too long. The current backlog of existing sites under CERCLA and on the NPL is large, and the backlog is expected to grow at a rate that far exceeds the current funding levels and the time required to clean up, delist, or achieve full closure status (GAO, 2010, 2013).

EPA relies on CERCLA as the key legal authority to require removal and remediation at sites where mining wastes pose a hazard to human health or the environment even though they may be considered "low hazard" and exempt from solid waste regulations (Housman, 1994). "Without this Superfund safety net, persons suffering environmental damages from mine sites would have to rely on common-law remedies such as trespass, nuisance, and negligence," (Houseman, 1994, 8).

State of New Mexico environmental legislation. Table 3 presents the major state environmental statutes and guidance that are applicable or relevant regulatory requirements for cleanup work under the 5YPlan. As early as 1963, the State of NM adopted the Public Nuisance Statute as early that outlawed water pollution (Garber, 1984). NM adopted the

Water Quality Act in 1967 (Section 74-6-1 at sec., N.M.S.A., 1978). The act mandated adoption of water quality standards as a guide to water pollution control and the adoptions of regulations to prevent or abate water pollution. The NM Legislation created the Water Quality Control Commission (WQCC) to adopt the standard and regulations. The WQCC established standards for some of the most common water contaminants and regulations that required anyone who discharges a potential ground water contaminant onto or below the surface of the ground to notify the state agencies of their activities. NM was one of the leaders in the development of water quality standards to protect ground water. The New Mexico Environment Department (NMED) is “the constituent agency with primary responsibility for implementing and enforcing the regulations and standards adopted by the Commission” (NMED, 2014).

NM stream standards are enforced through a joint effort with the EPA under the CWA and all discharges to surface waters require an NPDES permit from the EPA (Garber, 1984). NM stream standards are applicable to perennial and intermittent bodies of water that reside within the state (NMAC, 2000). The definition of “surface water” according to NMAC 20.6.4 does not include private waters that do not combine with any other surface or subsurface water (NMAC 20.6.4.S.5).

The state regulatory focus is on the usability of the water by both the discharger (current user) and future users. A discharger is allowed to use the water and release some contaminants so long as they do not adversely impair the designated uses of the stream. The state may require a ground water discharge permit (DP) be obtained if an operation has the potential to release liquids that may join with ground water (NMED, 2014). The basis for approval of a DP is a demonstration that the discharge of fluids on or to the surface will not cause any of the WQCC standards to be exceeded at any place in the present or reasonably foreseeable future (Garber, 1984). NM regulations allow for “reasonable degradation” of water quality so long as the standard for a given contaminant is not exceeded or designated use is not impaired. One consideration in the NM approach to protection of ground water quality using standards instead of specific effluent limits for each individual site is that the state did not have the funds and resources to address each site individually (Townsend, 1978, 954). Limited funds means that NM does not have adequate data to determine whether certain elements like molybdenum, selenium, and vanadium should be regulated by a permit. NM requested that EPA NPDES permitting for uranium mines incorporate state water quality standards, but the EPA was reluctant to do so because it meant translating those standards into effluent limits (Townsend, 1978).

When the state environmental agency DP program went into effect in June 1977, the agency sent notification of discharge requirements to 21 uranium mines and mills that started operation after June 1977 (Townsend, 1978). During the time of active uranium mine dewatering, the NM surface water quality standard for uranium was 5 mg/L. It was not until 2004 that the NM surface and ground water quality standard for uranium changed to 0.030 mg/L (WQCC, 2004). The revised NM standard for uranium is consistent with the federal Maximum Contaminant Level (MCL) standard of 0.030 mg/L for public drinking water supply (EPA, 2014d).

Under authority of the New Mexico Water Quality Act, the WQCC developed the ground water standards and permit/pollution prevention requirements (NMED, 2007, Chap 5., 92). The NMAC 20.6.2000 regulations require that all waters of the State with a total dissolved solids (TDS) content of 10,000 milligram per liter (mg/L) or less be protected for current and future use. The Discharge Permit (DP) regulations (NMAC 20.6.4000) are the cornerstone of the State's pollution prevention program because it requires entities that "*discharge onto or below the surface of the ground demonstrate that it will not cause ground water standards to be exceeded in ground water at any place of withdrawal for present or foreseeable future use, and not cause any stream standard to be violated*" (NMED, 2007, Chap. 5, 92). "*Enforcement of WQCC regulations for ground water pollution control is pursued as limited resources allow*" (NMED, 2007, Chap. 5, 94). Three methods are used by the state to achieve compliance: 1) voluntary compliance through communication and agreements; 2) Notices of Violations and Compliance Orders; and 3) civil lawsuits filed in state district court under the NM WQA or applicable portions of the Public Nuisance Statute or both (NMED, 2007, Chap. 5, 94).

New Mexico Mining Act. Prior to 1993 the hard rock mining industry was not required to conduct reclamation during or after active mining operations especially on private lands in NM (McIntosh, 1998). The purpose of the 1993 New Mexico Mining Act (NMMA) is to "*promote responsible utilization and reclamation of lands affected by exploration, mining or the extraction of minerals that are vital to the welfare of New Mexico*." The NMMA requires all mines and especially new mines to obtain permits, meet certain standards, develop an approved reclamation plan, and post financial assurance to support the reclamation plan (EMNRD, 2015a). A mining operation was not required to comply with the NMMA permit requirements if it did not produce marketable minerals for two years or more between 1970 and 1993. All existing and active mines were required to have an updated permit and a Close Out Plan in place by the end of 1995. The Close Out Plan has to be approved by the State and it must include a cost estimate to fully close the mine. The cost estimate will become the basis for the amount of financial assurance (bond) required as part of the updated mine permit.

Mining Act Reclamation Program. The New Mexico Mining Act Reclamation Program (MARP) is a permitting program for hard rock mines, and it has jurisdiction over exploration and conventional uranium mining activities. MARP does not cover in-situ leach uranium mining or uranium mill sites. The five uranium mine operations that are permitted under MARP are: 1) Rio Grande Resources' Mt. Taylor mine; 2) Rio Tinto Energy's JJ No 1/L-Bar mine; 4) Rio Algom's Old Stope mining properties; and 5) UNC's St. Anthony Mine (EMNRD, 2009). Under MARP the mine is required to have a closeout plan that demonstrates the work to be done to reclaim the permit area will follow a remediation standard *"to a condition that allows for the reestablishment of a self-sustaining ecosystem on the permit area following closure, appropriate for the life zone of the surrounding areas",* (EMNRD, 2015a). There is no remediation standard for radioactivity as a requirement under the MARP program. However, NM has developed guidance for the reclamation of existing uranium mines (EMNRD, 2014a).

Abandoned Mine Land Program. The New Mexico Abandoned Mine Land (AML) Program is for mines that were no longer operating by 1977. The AML Program is supported by funds from the tax on active coalmine production that goes toward the Abandoned Mine Reclamation Fund. The funds are used to reclaim coalmines prior to 1977 and under certain conditions, the funds can be used for non-coal mines. Mines are inventoried and a potentially responsible party (PRP) is identified to determine if they qualify for the AML Program. NM determined that over 50% of the uranium mines in the state (137 of 259) had no record any reclamation having occurred or currently required by a government agency (EMNRD, 2008). Since 1981-2004, AML has implemented 155 reclamation projects and addressed over 3,100 hazardous mine features in NM (EMNRD, 2014d). It is important to note that SMCRA reclamation projects cannot be within an area covered by UMTRCA or CERCLA activities.

Technical Factors and Considerations

The technical strategy to address legacy uranium sites in the 5YPlan is based largely on the CERCLA-Superfund process of assessment, remediation, closure, and monitoring (EPA, 1991). Figure 3 depicts a simplified illustration of the CERCLA-Superfund Process. Technical assessment of a site suspected of contamination with hazardous materials follows a sequenced approach consisting of phased investigations/remedial actions depending on the findings from each phase. A Phase I investigation is a limited evaluation of site conditions based largely on existing information, and ideally though optional, including a brief visit to the site to take field measurements, photographs, and descriptive notes (EPA, 1991). A Phase II investigation provides new information about site contamination conditions through systematic collection and laboratory analysis of soil, ground water, and/or air samples to more confidently identify and confirm the location(s), type(s) and form(s) of contaminant releases at the site. If the Phase II investigation determines there has been a release of hazardous contaminants at and/or from the site above background concentrations or regulatory standards, then remedial action could be required to clean up the site.

Nature, extent and magnitude of contamination. The area of the land surface and the local ground water impacted by legacy uranium activities has to be assessed to determine the nature, extent and magnitude of contamination at and/or from the site (EPA, 1991). Technical investigations determine whether contamination footprint of a uranium mine varies depending on: the areal extent of land surface that was physically disrupted by mining operations; and the amount of waste and types of waste left on site (EPA, 2008a). Environmental factors such as the local climate, elevation, geology, and hydrology play a role in the evaluation and remediation of a site contaminated with hazardous materials (EPA, 1991).

The "background" concentrations of contaminants in soil and water are a very important technical characteristic that needs to be determined at a site in order to help quantify the magnitude and extent of the man-made release compared to natural levels (EPA, 1991). Background contaminant levels are also used to set cleanup levels for a site. For ground water, background levels are typically determined by sampling and analyzing the first, often up gradient, non-impacted zone of alluvial and/or bed rock ground water beneath the site (EPA, 1991). The ground water zone potentially impacted by legacy uranium contamination requires properly placed and constructed private wells or monitoring wells that can be sampled and checked for water quality compliance with federal and state of New Mexico standards. Also, if a uranium mine was a "wet mine" as compared to a "dry mine," then the potential area of impact requiring assessment can be significantly larger because the mine water discharge containing contaminants into ephemeral drainages extends the size of the mine waste footprint on the surface and in the subsurface.

For soils, the magnitude of man-made contamination is assessed by comparison to background levels of metals and radionuclides that occur naturally in un-contaminated soil samples. Reliable and representative background levels in soil are best determined by careful sampling of an area undisturbed by mining that is nearby and similar in geology and soil characteristics (EPA, 1991, 2006). The surface of a legacy uranium site can be assessed by aerial radioactive surveying or on the ground using radiological survey meters and the systematic collection and laboratory analysis of soil samples for radionuclides. The size and design of the radiological survey and the number of soil samples required to evaluate a uranium mine depends on factors such as the size of the property, the locations of mine operational remains and waste piles, and the heterogeneity of soil and rock at the site. EPA conducted aerial radiological surveys of specific sections of the Grants District and mapped the areas of surface soils with elevated levels of radioactivity above background (EPA, 2011a & 2011b).

To check if the levels of contaminants could pose a risk to human health and the environment, the risk from the site to persons living near the site is typically evaluated using the Hazard Ranking System (HRS; EPA, 1991). A site HRS score can be used to support placement of the site on the National Priority List (NPL) where it will be investigated/remediated under EPA regulatory oversight according to the Superfund Process of remediation and closure, e.g., the Jackpile Mine (EPA, 2012a). An HRS score of 28.5 or greater qualifies a site for placement on the NPL. Part of the HRS scoring to obtain a value of 28.5+ depends on having people living/working close to the site, or there is a potential for human exposure to contaminants from the site (EPA, HRS, 1991).

Cleanup considerations. The assessment of the amount and extent of contaminated soil and ground water requires systematic sampling at each legacy site in order to define the horizontal and vertical extent of the contamination. Investigation personnel require technical and safety training in the operation of field instrumentation and the protocols for representative sampling of soil and ground water that contains elevated levels of radionuclides and metals. Evaluation reports that accurately describe the extent/magnitude of contamination based on credible field and laboratory data have to be written to build an administrative/technical record for the site. Once a cleanup level for radionuclides in soil is decided, the work level-of-effort and funding that is needed to cleanup a site must be estimated and documented.

The actual cleanup can require complex and intensive activities because it involves earthwork equipment, field meter readings, engineering, worker health and safety, and laboratory sample results to verify the cleanup as performed is satisfactory according to regulatory standards. An evaluation must be performed to determine whether to consolidate contaminated material at each site, or to try and consolidate contaminated material at a regional disposal facility. Disposal on site is the most convenient and cheapest cleanup design, but it requires periodic monitoring and maintenance to ensure the engineered disposal of mine waste is protected. Consolidation of contaminated material at a single, central disposal facility requires transport of material from mine site to the disposal facility that will also require periodic, long-term, monitoring and maintenance.

The strategy to cleanup a legacy uranium mine encompasses the area and volume of impacted soil (tons or cubic yards) for cleanup and long-term monitoring/management. The volume of uranium mine waste in one acre to a depth of one-half foot equates to approximately 806 cubic yards or 1,209 tons of material per acre (43,560 ft^2/ac X 0.5 ft = 21,780 cu ft^3/ac X 0.037037 yd^3/ft^3 = 806 yd^3 X 1.5 ton/yd^3 = 1,209 tons/ac!). If 25 acres contained uranium mine waste to a depth of one-half foot would equate to approximately 30,225 tons of material for potential cleanup. EPA reports that on average as much as 50 acres could be impacted at a major uranium mining site (EPA, 2008a).

There are many sources of information that describe the evidence for surface and ground water contamination from legacy uranium operations in the Grants District (Gordon, 1961; West, 1972; Townsend, 1978; Gallaher & Goad, 1981; Gallaher & Cary, 1986; Schoeppner, 2008; EPA, 2010; and NMED, 2010). The Arroyo del Puerto received discharge water from tailings pond seepage, ion exchange plants, and mine dewatering (EPA, 1975; Gallaher & Cary, 1986). The water was high in total dissolved solids (TDS), ammonia, chloride, nitrate plus nitrite, and radium. Discharge from ion exchange plants contained elevated levels of TDS, pH, trace metals, and radionuclides. Mill water discharges often exceeded the EPA National Pollution Discharge Elimination System (NPDES) permit criteria for radium and uranium (EPA, 1975). Legacy mill process and mine water that were discharged to the Arroyo del Puerto and San Mateo Creek for over 20 years infiltrated the alluvium and possibly bedrock aquifers.

Although mine dewatering ended and there is no longer visible surface watering flowing in nearby drainages, the native ground water quality exceeds state and federal standards in some locations where wells are available for sampling (NMED, 2010). As noted by NMED in the 2009 Health Advisory for the SMC Basin, private well water may contain contaminants in excess of federal drinking water standards, and owners are advised to get their well water quality tested (EPA, 2010). The extent of ground water contamination in the upper to middle SMC Basin is not well known, and it could be spreading due to natural conditions and anthropogenic activities like pumping for municipal, agricultural, industrial, and domestic use.

In the lower SMC Basin it appears that ground water contamination from the Bluewater Disposal Site is possibly spreading past the facility boundary and down gradient in the San Andres-Glorieta (SAG) Aquifer (DOE, 2014c). Based on review and evaluation of historical documents and information, approximately 5.7 billion gallons of tailings waste water seeped through impoundments at the mill over a nearly 40 year period, and it infiltrated/mixed with the SAG Aquifer and the Rio San Jose Alluvium. The 2014 DOE assessment of "Bluewater-derived uranium" indicates that that contamination with "mill-related constituents" is migrating beyond the site boundary. In fact, according to the evaluation of ground water contaminant transport and spatial water sampling results for uranium from wells completed in the SAG Aquifer, DOE estimates it is plausible that uranium from Bluewater migrated eastward and could have reached the Homestake mill area by 1980 (DOE, 2014c, 183).

Financial Costs

The DOE estimated that the cost to finish cleanup at approximately 24 uranium mill sites under the UMTRCA program in 1998 would be $2.3 billion (GAO, 1995). The estimated average cleanup cost per ton of U.S. UMTRCA Title I uranium mill tailings is $68.37 (BMWi, 1995). As of 1994 total mill tailings reclamation and decommissioning costs as of 1994 at three sites in NM were $19.4 million for the Ambrosia Lake site; $8.6 million for the United Nuclear, Church Rock site; and $15.4 million for the L-Bar site.

By 1996, DOE had not started ground water cleanup at any of the 24 mill sites, and the type and extent of contaminated ground water at each site was not fully known (GAO, 1995). The remedial alternatives DOE considered appropriate for addressing ground water contamination at a mill site included leaving the ground water as it is; allowing it to cleanse itself over time (natural flushing); or using active pump and treat to clean the water (GAO, 1995). DOE concluded that the federal government's cleanup costs associated with uranium mill sites is unknown until issues regarding cost sharing; preferred remedial activities; Grand Junction, CO cleanup costs; and long-term site care responsibilities are resolved.

The cost to cleanup contaminated soil and rock from a uranium mine varies with each specific site and factors like location, the regulatory cleanup standard, the volume of material, and the disposal alternative, i.e. disposal on site (least expensive) or disposal off site (most expensive). Data from the DOE Energy Information Administration study (2005) revealed that the cost of reclamation (disposal on site) as of 2000 without any site monitoring for 21 uranium mines ranged from a low of $2,337 per hectare ($950 per acre) to a high of $269,531 per hectare ($109,000 per acre). The average total reclamation cost per uranium mine was $13.9 million. In the arid Southwest where most uranium mines are located, small mines with a disturbance of less than 10 hectares (24.7 acres) are estimated to cost approximately $45,000 or less to reclaim. This type of reclamation requires that waste piles be buried back in the original open pit or in underground mineshaft; the mine waste regulatory cleanup standards be higher; and the mine opening be covered with rock. If the mine reclamation was to follow the remediation requirements under CERCLA and potentially longer duration human exposure scenarios of future on site land use, the mine cleanup cost would be significantly higher (Setlow & Peake, 2007).

The DOE prepared a report to Congress on abandoned uranium mines (AUM) in the U.S. that provided uranium ore for atomic energy defense activities (DOE, 2014b). This report used a "bottom-up" cost model based on six mine production-size categories to develop cost estimates for reclamation and remediation. The range of costs per production-category is only a preliminary estimate and not to be used to estimate the cleanup cost for a specific mine (DOE, 2014b). Reclamation is defined as activities focused on mitigating physical hazards and site stabilization (closing openings, consolidation, erosion protection, fencing, signage). Remediation includes reclamation activities, but also the cleanup of soils and ground water to risk-based cleanup standards. Remediation cost estimates are highly variable and can range from $215,000 to $205 million per mine depending on the size of the mine and the number/type of features. The DOE 2014 AUM cost estimates do not include any estimation of the cost to cleanup ground water. Table 4 provides a summary of the remediation and reclamation costs for AUM production-size categories.

Only a few legacy uranium mine sites in the Grants District have any actual or estimated cost information. EPA reports that the actual costs to conduct interim removal actions at the NECR Mine and Quivira Church Rock Mine are $56/ton and $74/ton, respectively (DOE, 2014b). The San Mateo Mine on U.S. Forest Service land in the eastern part of Ambrosia Lake took nearly 25 years to finish since it was first evaluated and recommended for cleanup, and it cost $5 million ($33/ton) to cleanup approximately 180,000 cubic yards of material (SAIC, 2009 & Boyett, 2012). Cleanup of mine waste at the NECR Mine involves approximately 1.2 million tons of material and an estimated total cost of $43 million ($36/ton) to dispose at the UNC mill site under an amended NRC license (EPA, 2009a; 2012 & DOE, 2014b). The total estimated cost to cleanup the St. Anthony Mine without any contingency and escalation is approximately $25,361,000 ($3.90/ton) for approximately 7,809,000 cubic yards (UNC, 2010).

Chapter 5: Evaluation of the Five-Year Plan

In this chapter each objective and the Action Plan Tasks prescribed for that objective are evaluated for completion according to three major assessment criteria: Law and Regulatory Programs; Technical Factors and Considerations; and Financial Costs.

Objective 1: Assessment of Water Sources for Contamination

Action Plan Tasks:

1) Continue sampling ground water supply and interpret results, help impacted well owners where possible;
2) Initiate regional hydrogeologic and geochemical studies to evaluate/model contaminants of concern (COC) fate and transport;
3) Evaluate public water supplies for contamination;
4) The DOE will work with other agencies regarding ground water contamination assessment at DOE facilities; and
5) Provide public updates on this objective work twice a year.

Laws and regulatory programs. The primary regulatory programs that apply to Objective 1 includes: 1) the Clean Water Act (CWA); 2) the Safe Drinking Water Act (SDWA); the Uranium Mill Tailings Radiation Control Act (UMTRCA); the Comprehensive Environmental Response, Compensation, Liability Act (CERCLA); the New Mexico Water Quality Act (NMWQA) NMSA 1978 Section 74-6-1 et seq.; and the New Mexico Water Quality Control Commission Regulations 20.6.2 NMAC for a ground water Discharge Permit (see Tables 2 and 3). Ground water contamination associated with former uranium mill sites in the GMB addressed by continued monitoring and/or remediation under regulatory requirements of: UMTRCA (all sites); CERCLA (UNC Church Rock and

Homestake); and 20.6.2 NMAC (Homestake and Rio Algom). According to information from EPA, DOE, NRC, and NMED websites, each site performed activities involving monitoring, sampling, remediation (where applicable), and reporting. These activities satisfied the completion of Objective 1 Tasks 1, 3, 4, and 5. Task 2 will require more resources, investigations, and time before a full hydrologic and geochemical understanding can be reached about fate and transport of legacy contamination in ground water of the SMC Basin.

With regard to 5YPlan Objective No. 1, Task 2 (*regional ground water study*) there are no specific federal or state regulatory requirements that drive all of the activities necessary to accomplish Task 2 unless there is clear and significant evidence that the ground water contamination problem is anthropogenic and a current risk to human health. EPA indicated in the latest 2014 5YPlan Update, that under CERCLA it was planning and implementing a water quality investigation of parts of the SMC Basin (EPA, 2014b). The 2010 NMED DP list indicates only a few uranium industry dischargers in the SMC Basin (Arco Bluewater, Quivira, Rio Algom, and Homestake). The St. Anthony Mine in the eastern part of the GMB is under the MARP permit MK006RE and was working in late 2010 to complete a cost estimate for mine closure according to their Closeout Plan (MWH, 2010). A 2002 NMED press release described a proposed ground water investigation at the St. Anthony mine (NMED, 2002). A 2011 consultant report for the JJ No.1/L-Bar Mine indicated a Stage 1 Abatement Plan was submitted to NMED in 2006 for further ground water characterization (Intera, 2011).

Technical factors and considerations. The primary technical challenge to accomplishing Task 2 of Objective 1 is that there is no implementation plan for a comprehensive regional ground water investigation, and there is a lack of strategically located and properly constructed monitoring wells throughout the study area. EPA acknowledged the lack of a properly designed monitoring well network around mines and mills in the SMC Basin area as early as 1975 (EPA, 1975). Even though monitoring wells and programs are present at and around legacy mill sites today, there is an overall absence and inadequate number of monitoring wells to support a regional ground water investigation (NMED, 2010). The latest EPA 5YPlan update describes a plan and activities to assess ground water quality in the SMC Basin in late 2014 that includes determination of hazardous material releases that are above background.

The 5YPlan describes two technical factors that have to be considered in the implementation of tasks for this objective: 1) identification of background water quality that is unimpaired by legacy activities; and 2) differentiation of contamination from natural as compared to anthropogenic (man-made) sources. Clear evidence of attribution is an important factor for consideration when proceeding with regulatory enforcement actions or site management responsibility. For example, the 2014 DOE Bluewater status report suggests the level of natural uranium in the SAG Aquifer is about 0.010 mg/L, and any ground water from this aquifer with a uranium level greater than 0.010 mg/L may include some "Bluewater derived uranium" (DOE, 2014b). The 2010 NMED geochemical report used uranium isotopes to support a hypothesis that at least one offsite well location with elevated uranium levels is possibly attributable to contaminated ground water at a nearby mill site. The U.S. Geological Survey (USGS) conducted a limited ground water quality study of the upper eastern part of the SMC Basin in 2011which does help define background water chemistry (Langman, Sprague, & Durall, 2012).

Financial cost. With regard to Objective 1 Task 2, 5YPlan activities during 2010-2014 did not result in a work plan for a regional ground water investigation including a total cost estimate for such work. The 5YPlan provides some cost estimate information regarding analytical costs, monitoring well construction, and aquifer testing. Based on an estimated water sample laboratory analytical costs of $50,000 for two years, approximately 40 samples could be analyzed at a cost of $1,200 per water sample. The 5YPlan indicates the cost estimate for an individual monitoring wells varies and can range between $25,000 and $100,000 depending on well depth and location. Aquifer testing of a single well or group of wells varies and ranges between $5,000 and $50,000. Using mid-range cost estimate values, the total cost to construct ($60,000), test ($25,000), and sample ($1,200) a single monitoring well one time yields a total cost of $86,000 ($60,000 + 25,000 + $1,200). Multiply this same value at 10 locations yields a total cost estimate of $860,000 for 10 wells. Unfortunately, without an investigation plan, the number and location of wells needed for a regional ground water study are unknown. EPA guidance on approaches and methods to develop cost estimates for monitoring ground water are available to support development of a regional investigation plan in the SMC Basin (EPA, 1997).

Overall evaluation. Tasks 1, 3, and 4 have been completed and ongoing. During 2010-2014 sampling of public water supply wells, private wells, and monitoring wells by NMED, DOE, and Homestake satisfied the completion of Tasks 1 and 3. DOE completed Task 3 and continues to monitor ground water conditions at the Bluewater site. Task 5 twice a year public meeting in the Grants, NM area was not always completed but 5YPlan updates have been provided annually on EPA website. Task 2 has not been completed but some investigation and monitoring activities did contribute new information (NMED, 2010 & DOE, 2014b).

Objective 2: Assessment and Cleanup of Uranium Mines

Action Plan Tasks:

1) Review, compile, prioritize sites for assessment screening to identify data gaps (*prioritize sites*);
2) Conduct and document site screenings on 96 mines by end of September 2011 – mitigate sites with immediate and substantial threat (*screen sites*);
3) Assemble preliminary assessment reports and plan for phased investigation as prioritized (*plan phased studies*);
4) Initiate regional hydrologic-geochemical studies (*initiate regional studies*);
5) Systematically investigate, document, prioritize, enforce, remediate, and close sites (*clean up sites*);
6) Develop integrated protocols for site characterization and cleanup goals (*develop protocols*); and
7) Provide public updates on this objective work twice a year (pu*blic updates*).

Laws and regulatory programs. The primary regulatory programs that apply to this objective includes: 1) CWA; 2) SDWA; 3) UMTRCA; 4) CERCLA; 5) 36 CFR 228 (USFS mining regulations; USFS, 2013); 6) 43 CFR 3809 (BLM degradation protection of public lands: BLM, 2013); 7) 20.6.2 NMAC; and 8) the New Mexico Mining Act Reclamation Program (MARP).

As discussed earlier, there are no federal regulations designed specifically to address the cleanup of uranium mines. If soil and water contamination from a uranium mine pose a significant threat to the environment and human health, then EPA and other federal agencies can use their CERCLA authority to conduct urgent mitigation response actions and/or to require the potentially responsible party (PRP) to conduct investigations and remediation activities. Otherwise, if there is not a substantial risk posed by the site, then federal agencies are left to seek voluntary enforcement-compliance from PRPs and to use private resources to reclaim and remediate mine sites on private and federal lands. Of the 97 uranium mines identified in the 5YPlan, 78 were assessed and 19 assessments were pending (EPA, 2012c). CERCLA 104(e) letters were issued to five PRPs and efforts to identify additional PRPs will continue.

The state MARP program requiring an approved mine reclamation plan be permitted and bonded went in to effect in 1993 with a deadline to complete permitting by the end of 1995 (EMNRD, 2015a). The state has been enforcing mine reclamation and close out through the MARP and DP programs at a limited number of legacy uranium mine sites. How many of the stated 96 sites are under a state program is unknown. As noted earlier, under the authority of 20.6.2 NMAC, the state has the authority to require that former and existing mine owners with a permit assess and abate potential threats to water quality. Even though the state regulatory programs do not have specific cleanup criteria approved for uranium mine cleanup, EMNRD and NMED developed draft assessment and cleanup guidance documents for existing and new uranium mines (EMNRD, 2014a & 2014b).

Technical factors and considerations. The EPA conducted aerial radiological surveys and limited surface assessments for the purpose of enforcement in the Ambrosia Lake area (EPA, 2010, 2011a, 2011b). Aerial radioactivity survey maps revealed the location and concentration of elevated surface radioactivity at legacy sites according to property ownership (EPA, 1991, 2011a). EPA used the survey map results and contacted a few site owners for permission to conduct limited surface assessments to determine if a hazardous material release (radioactivity and metals) had occurred (EPA, 2013b). According to the aerial survey data, several legacy mine sites display elevated levels of radioactivity many times above background levels and these sites are under state permitting (MARP or 20.6.2 NMAC DP) for mine closure and/or abatement (EMNRD, 2009 & NMED, 2011).

During the 2010-2014 period the agencies accomplished work under Tasks 1 (*prioritize sites*), 3 (*screen sites),* 4 (*regional ground water studies*), and 5 (*clean up sites*). But these tasks require more time and resources to fully complete, particularly Tasks 4 and 5. Task 4 in Objective 2 is the same as Task 2 in Objective 1 (*a regional ground water hydrologic-geochemical study*). Task 5 is the systematic cleanup of legacy uranium mines based on an implementation strategy including enforcement to obtain the resources to perform the work. With respect to Task 2, EPA and NMED did not complete all the site screening reports for the 96 mines by September 2011, but they did complete approximately 73% of those screenings (EPA, 2012c).

The screening reports for the mines help define where data gaps exist and they also indicate the need for future assessment work. The agencies used the screening reports to designate the agency assigned responsibility for the final cleanup of the site. Task 6 (*cleanup protocols*) was addressed by draft guidance for the cleanup of existing and new uranium mines developed by the Mining and Mineral Division (MMD) of EMNRD, and NMED (EMNRD 2014a & 2014b). Task 7 (*public updates*) requires two public updates per year on the progress for this objective that was addressed by annual meetings and updated fact sheets published by the EPA.

Under Task 5 (*clean up sites*), two legacy uranium mines were addressed during the 2010-2014 period: the San Mateo Mine on USFS lands, and the Jackpile Mine on the Laguna Pueblo. A discussion of the Jackpile Mine follows in a later section because the Plan developed Objective 5 (*consultation-investigation of Jackpile*) was specifically developed for this large site. The San Mateo Mine on USFS land completed remediation in 2013 (USFS, 2013 & Boyett, 2012).

The cleanup of uranium mines is a project that requires engineering, administration, and maintenance for decades due to the long-lasting radioactivity hazard from the uranium series of daughter isotopes primarily radium and radon gas. Moreover, there is the potential for a release of hazardous constituents from waste rock materials through weathering and geochemical processes. The 2014 DOE report defines the terms "*reclamation*" and "*remediation*" because they are different but related terms that involve different scopes and end states of work. "*Reclamation focuses on mitigating the physical hazards and stabilizing the site, while remediation involves all of the reclamation scope plus remediating contaminated soils and ground water to a risk-based cleanup standard*" (DOE, 2014b, 3). It is not clear in the EPA 5YPlan, which mine sites are to be reclaimed and which sites are to be remediated, but it appears the current strategy is a combination of reclamation and remediation.

Final design of a uranium mine cleanup end state depends on a compliance standard for radioactivity in surface soil. A numerical value for the level of radium in soil is used as the compliance standard to achieve cleanup, and it is based on a land use scenario of human and environmental risk of exposure (EPA, 2008a; ATSDR, 2013, & EMNRD, 2014b). A radium soil compliance standard will be lower for a residential land use scenario (maximum exposure) as compared to a higher standard for a recreational land use scenario (minimal exposure).

Financial cost. The cost to perform the scope of work under Objective 2 (*Assessment and Cleanup of Uranium Mines*) requires substantial resources, time, and funding. The Plan calls for a standard protocol of assessment, cleanup, and verification for uranium mine remediation work. The cost to conduct a regional ground water investigation was previously discussed under Objective 1. Under Objective 2 the 5YPlan states that basic mine screening assessments range in cost from $10,000 to $20,000 depending on site size and complexity (EPA, 2010). Multiplying these costs times the number of sites, the total estimated cost range for screening assessments of the 96 legacy mines would be from $960,000 to $1,920,000. The estimated cost to complete a formal mine site investigation ranges from $210,000 to $1,000,000 per site (EPA, 2010). This results in a total estimated cost for site investigations of the 96 legacy mines ranging from $20,160,000 to $96,000,000. In theory, a funding value in this cost range could be spent on assessment level work without cleanup because of the logistics and labor required to survey each of the 96 mine site with field crews, data collection, laboratory sample analysis, and report writing.

The actual costs to clean up a legacy uranium mine could range from several thousand dollars to several million dollars per site depending on the cleanup standard and specific site conditions. Site-specific information includes the number of acres disturbed and levels of radioactivity and metals above background in soil and ground water are required to reduce the uncertainty in cleanup cost estimates. The cleanup of the Midnite Mine in Washington State is estimated to cost $205 million and cover 570 acres resulting in a cost of $360,000 per acre (EPA, 2013d). The cleanup of the Northeast Church Rock Mine is estimated to cost $43 million and cover 40 acres at a cost of $1.1 million per acre (EPA, 2009a). The cleanup of the San Mateo Mine cost $5 million and covered 40 acres at a cost of $125,000 per acre (USFS, 2013 & Boyett, 2012).

Using the 2014 DOE report and EMNRD information from 2014 along with the assumption that two tons of uranium ore are typically required to produce one pound of uranium oxide, rough approximations of ranges of cost estimates were calculated for AUM inventory sites and the 96 legacy uranium mines. Using the information from the 2014 EMNRD presentation to the state legislature and 29 medium-large size AUMs with no reclamation documentation, an estimated cost to reclaim and remediate this number of sites was calculated (EMNRD, 2014d). The estimated cost to *reclaim* 29 medium-large AUMs ranges from $7,830,000 to $19,720,000, and the estimated cost to *remediate* 29 medium-large AUMs ranges from $75,400,000 to $191,400,000. Conservatively assuming that the 96 legacy mines were also medium to large in production size, the corresponding cost to *reclaim* 96 sites is estimated to range from $25,920,000 to $65,280,000. The conservatively estimated cost to *remediate* 96 legacy uranium mine sites ranges from $249,600,000 to $633,600,000. As noted in the 2014 DOE report these cost estimates are rough approximations that contain assumptions, uncertainties, and no consideration for any ground water cleanup.

Overall evaluation. Tasks 1, 2, 3, 4, 5, and 6 show some progress but were not completed. Task 7 twice a year public meeting in the Grants, NM area was not always completed but 5YPlan updates have been provided annually on EPA website.

Objective 3: Contaminant Assessment, Cleanup and Long-term Management of Former Uranium Milling Sites

Action Plan Tasks:

1) DOE continues long-term stewardship at two sites;
2) DOE continues to work with NMED to better understand ground water quality at DOE sites;
3) DOE installs additional monitoring wells at Bluewater Disposal Site; and
4) Updates on the progress of this objective are provided to the public twice a year.

Laws and regulatory programs. The1978 UMTRCA is the federal legislation specifically passed to address the cleanup and long-term management of uranium mill sites. Mill reclamation/remediation must meet UMTRCA compliance standards for air (radon gas emission) and soil (radium) radioactivity. However, the contamination of ground water is more complicated and compliance with the NRC license Ground Water Protection Standards (GWPS) is a more difficult challenge. If the PRP can show that the remediation technology available to address ground water contamination is not cost effective and will not meet the GWPS, then another regulatory mechanism (Alternate Concentration Limit or ACL) is used to enable the site to proceed with the closure and eventual license transfer to the DOE (NRC, 1997, 2013).

The PRP can request and the NRC can grant an ACL GWPS for those COCs that are persistent, significantly elevated, and are not responsive to remedial attempts to reduce their levels to standards. The ACLs are set at or slightly above the current contamination level so that regulatory compliance, site closure, and license transfer are possible. For example, the Bluewater site applied for and was granted ACLs in 1997 under the NRC license for certain contaminants that enabled the site to meet NRC requirements for site closure and license transfer to the DOE for long-term monitoring (DOE, 2014c). The state has no regulatory jurisdiction regarding the ground water cleanup standards for a mill site, but if there is a contaminant release outside the property boundary, then 20.6.2 NMAC applies and a DP and abatement would be required.

Technical factors and considerations. Each mill site in the Grants District has specific and unique hydrogeologic conditions and a different configuration of ground water contamination beneath it. All of the mill sites contaminated underlying ground water with elevated concentrations of radionuclides, metals, dissolved solids, and acids or alkalinity. Each of the four mill sites required/requires a different approach to address ground water contaminated in excess of NRC GWPSs. DOE installed 10 new monitoring wells at Bluewater in 2011-2012 in the alluvium and San Andres-Glorieta Aquifer in order to investigate exceedances of GWPSs and the problem of mill contamination moving past the site boundary. DOE also completed a hydrogeologic and geochemical status report for the Bluewater site (DOE, 2014c).

DOE and the UMTRCA program are not fully capable of addressing long-term ground water plume management beyond facility boundaries because they have to secure access and permission from owners to sample private wells and to site/install new monitoring wells to continue to conduct assessment work. Off site ground water data is a critical component of that assessment. There is no properly designed off site monitoring well network for the Bluewater site and basin west of Homestake (EPA, 1975 & NMED, 2010). So there is a reliance on sampling private water supply wells to fill the spatial data gaps in ground water information. Homestake has installed numerous monitoring wells as part of their complex water treatment and monitoring system that provides some information on the Bluewater contaminant plume extent (EPA, 2011c).

Financial cost. The DOE Legacy Management (LM) program is responsible for all monitoring and maintenance duties at 22 uranium mill sites (DOE, 2014b). The 5YPlan estimated approximately $600,000 to $1,000,000 would be necessary for an off site assessment of potential ground water contamination at the Bluewater Disposal Site (EPA, 2010). The original amount of funding from the PRP (Atlantic Richfield Company) for long-term care of the Bluewater site was $635,135 when the site and NRC License SUA-1470 was transferred to the DOE in 1997 (NRC, 1997). In 2009-2010, following an examination of monitoring well construction deficiencies and the design of the existing well network, DOE determined it was technically appropriate and necessary to construct replacement and new wells at Bluewater to fill large data gaps. The funding to construct these additional wells in 2011-2012 has probably consumed the remainder of the $635,135 when the site transferred to the DOE in 1997.

Sources and/or mechanisms to provide DOE with supplemental funding to continue Bluewater on site monitoring and off site ground water investigations are unknown. DOE is not eligible to receive reimbursement for ground water investigation costs under UMTRCA because it is a Title I site. The original PRP, Anaconda-Atlantic Richfield Company (ARCO, a subsidiary of British Petroleum-BP) has the financial resources to provide additional funding but UMTRCA may not have the clear and specific requirements that the PRP provide supplemental funding beyond the original funding amount. The need for DOE to continue work under Objective 3 Task 2 through additional water sampling and installation of off site monitoring wells requires supplemental funding. The remaining scope and cost to address the issue of mill contamination moving past the Bluewater property boundary are unknown at this time.

Overall evaluation. Tasks 1, 2, and 3 have been completed. DOE continued monitoring at the Bluewater, UNC Phillips, and L-Bar sites. During 2010-2014 DOE installed additional monitoring wells at the Bluewater site and completed a site evaluation report. Task 4 twice a year public meeting in the Grants, NM area was not always completed but 5YPlan updates have been provided annually on EPA website.

Objective 4: Assessment and Cleanup of Contaminated Structures

Action Plan Tasks:

1) Continue to work with residential structure owners to identify contamination;
2) Conduct public outreach to facilitate an iterative process of assessment, prioritized removal, mitigation, and assessment; and
3) Provide updates on the progress of this objective to the public twice a year.

Laws and regulatory programs. Residential soil and surfaces are field tested for elevated gamma radiation above background and sampled for laboratory measurement of radionuclides (EPA, 2008a). EPA follows the CERCLA-Superfund Process, and residential properties are assessed and mitigated for radioactive contaminants including radon according to guidance developed for CERCLA sites with radioactive contamination (EPA, 2008a). Regulatory requirements for soil and structure cleanup at CERCLA sites are described in 10 CFR 40 Part 192 and Appendix A, I, Criterion 6(6). EPA guidance for cleanup under a residential exposure-risk scenario generally sets the remediation criteria for carcinogens (including radioactivity) at a level that is within an upper bound lifetime cancer risk to an individual in a range between 10^{-4} to 10^{-6}. This risk range equates to a 1:10,000 to

1:1,000,000 excess chance of contracting cancer above the normal risk of contracting a cancer during person's lifetime.

Technical factors and considerations. EPA assessed 891 structures and remediated 128 sites as of March 2014 (EPA, 2014a). Nineteen more sites remain to be remediated in the Mormon Farms area of Milan, NM near the Homestake Site to a health-based action level of 3.5 picoCuries per gram (pCi/g) of radium-226, which includes background (EPA, 2013c). Finding an acceptable location for temporary stockpiling of removed soil may present a challenge because the property owner must be willing to store contaminated soil on their property and trust that there will be no legal issues or ramifications. Ideally, a temporary soil storage facility is conveniently located close to the removal area in order to minimize truck hauling time and distance. The amount of soil removed dictates the size of the temporary storage facility required and level of effort required to transport removed soil to a licensed, permanent disposal facility. There is no licensed, commercial radioactive waste disposal facility in NM (NRC, 2013).

Financial cost. Very little information is available to evaluate the financial costs to accomplish Objective 4. The EPA Office of Emergency Response that conducts the residential assessment and remediation work on residential structures has not made detailed cost information available in the EPA 5YPlan public updates with the exception of the Mormon Farms Memorandum. The estimated cost to remediate 19 residential properties south of the Homestake site to a standard of 3.5 pCi/g Ra-226 is $3,462,970 which results in an average cost of $182,262 per site (EPA, 2013c). The remaining scope of work and estimated costs to complete Objective 4 are unknown.

Overall evaluation. Tasks 1, 2, and 3 are completed. EPA and the team of agencies responsible for implementation of Objective 4 have satisfied all of the Action Plan Tasks called for in the 5YPlan according to the implementation time line. Public outreach, assessments, mitigations, and removals continue at residential structures and properties for elevated levels of radium-contaminated soil and unsafe levels of indoor radon gas.

Objective 5: Jackpile Mine on Laguna Pueblo

Action Plan Tasks:

1) Continue consultation with the Pueblo;
2) Continue work as described in the Memorandum of Understanding (MOU) between the Pueblo; and
3) EPA will conduct a Preliminary Assessment (PA) and Site Inspection (S) at the Jackpile Mine;
4) EPA will issue twice-yearly updates to the public on the progress of assessment and investigation at the Jack Pile Mine.

Laws and regulatory programs. The primarily legislation that applies to the assessment and remediation of the Jackpile-Paguate Mine are CERCLA, CWA, CAA, SDWA, the Native American Graves Protection and Repatriation Act; the National Historic Preservation Act; the Archeological Resources Protection Act of 1979; and the American Indian Religious Freedom Act (also see Appendix A, Table 1 of the EPA Five-Year Plan). Negotiations between the Bureau of Indian Affairs, the Bureau of Land Management, the Atlantic Richfield Company, and the Pueblo of Laguna in 1986 designated the responsibility for reclamation of the Jackpile-Paguate Mine to the Pueblo of Laguna according to an

Environmental Impact Statement (EIS) for the Jackpile-Paguate site and a Record of Decision (EPA, 2012a).

In order to promote tribal economic benefit and utilization of the local skilled work force, the Pueblo of Laguna formed the Laguna Construction Company and conducted mine reclamation at the Jackpile-Paguate site from approximately 1990-1995. A 2007 Record of Decision Compliance Assessment determined that post reclamation conditions at the site did not meet compliance criteria for final earthen cover, surface water quality standards, and ground water quality standards (OA Systems Corporation, 2007 & EPA, 2012a).

Following the CERCLA Process, EPA conducted a site inspection (SI) in 2010 and an Expanded Site Inspection (ESI) in 2011 for the Jackpile-Paguate Mine (Weston Solutions, 2010 & 2011, & EPA, 2012a). Using the historical information compiled, new field and laboratory data along with the CSM, EPA conducted a Hazard Ranking System (HRS) scoring evaluation of the Jackpile-Paguate Mine for the surface water exposure pathway only. The Jackpile Mine HRS score was 50 and a value above 28.5 qualified the site for consideration of placement on the NPL (EPA, 2012a). EPA placed the Jackpile Mine on the NPL in December 2013 (FR 75475, December 12, 2013).

During the next Five-Year Plan period 2015-2019, the CERCLA Process will require that the various steps under the Remedial Investigation and Feasibility Study (RI/FS) be implemented to characterize the nature and extent of the release of COCs from the mine to the environment (see Figure 3 for Remedial Phase). Alternatives of remedial action will be studied for their feasibility to mitigate the COC releases. The RI/FS will be used to support a Record of Decision (ROD) for the Jackpile-Paguate Mine that will define the cleanup standards and remedy for the site. The PRP (ARCO) will likely have to negotiate an

Agreement On Consent (AOC) with EPA within the next year before planning and implementation of the RI/FS work can begin.

Technical factors and considerations. The data and interpretation provided in the HRS Documentation Record for the Jackpile-Paguate Mine indicates there is a significant amount and large extent of radionuclide and select heavy metal contamination in the mine areas and along the Rio Paguate stream channel down to and including the sediment trapped in the Paguate Reservoir (5.4 miles down from the mine). Approximately, 2,656 acres are potentially impacted by mining activities (EPA, 2012a). Elevated levels of uranium and manganese are present in surface water, ground water, and stream sediments, in some cases many times above background and drinking water standards. Even though the Laguna Pueblo does not obtain its drinking water supply from the surface water system for the Rio Paguate, various wildlife and livestock use the surface water system as a water supply. The tribe runs approximately 1,500 cattle, and 800 elk in the watershed and the tribe consumes the animals (EPA, 2012a). Surface and ground water accumulate in the mine pits, pit water mobilizes COCs, and outflow into the Rio Moquino and Rio Paguate stream systems spreads the contamination.

The detailed evaluation and potential remedial alternatives for the Jackpile-Paguate Mine areas to be prepared for Objective 5 will likely describe a remedy designed to minimize the contact between surface water, ground water, mine ore, and mine waste. Potential removal of radium-contaminated soils and sediments along the Rio Paguate stream channel down to and including Paguate Reservoir according to 3.5 pCi/g Ra-226 standard under CERCLA would be a significant engineering and earthwork challenge. The amount of channel sediment that could potentially exceed the cleanup standard and require removal may constitute a very large volume of material. No analysis has been done to determine if removed soil could be used to backfill parts of the large pits created by the excavation of uranium ore to minimize COC contact with water. The full nature and extent of contamination at the Jackpile-Paguate area and the level of remedial effort that will be required to mitigate COC releases are unknown, but will be large because the impacted area is so large.

Financial cost. No specific or estimated cost information for assessment tasks related to the Jackpile Mine was provided in the 2010 EPA 5YPlan. Pending the outcome of negotiations between EPA and ARCO for the work under the RI/FS, the PRP can conduct the investigative work and remedial alternatives, or the EPA can conduct the work using government funds and seek reimbursement for the costs. For the sake of discussion, simple cost estimates to perform remediation of the Jackpile-Paguate Mine were approximated using information from other similar sites on Native American lands. Using the total estimated cost ($206,000,000) to remediate the 520 acre Midnite Mine in Washington State, a cost of $337,000 per acre was determined. A remediation cost of $337,000 per acre (Midnite Mine) multiplied times 2,656 acres (number of impacted acres at Jackpile-Paguate) results in a total remediation cost estimate of approximately $894,000,000 for the Jackpile-Paguate Mine. Similarly using the total estimated cost ($43,000,000) to remediate the 40 acre Northeast Church Rock (NECR) Mine in Gallup, New Mexico: a $1,075,000 cost per acre was determined. A remediation cost of $1,075,000 per acre (NECR Mine) multiplied times 2,656 acres (impacted acreage) results in a total remediation cost estimate of approximately $2,855,200,000 for the Jackpile-Paguate Mine. This simple analysis provides remediation cost estimates for the Jackpile-Paguate Mine ranging from $894 million to $2.9 billion, which at best provides an order of magnitude estimation.

Overall evaluation. Tasks 1, 2, 3, and 4 were completed during the 2010-2014 period. The implementation timeline indicates the MOU and the PA/SI would occur during 2010, and the remaining four years of activities (2011-2014) are blank. The Jackpile-Paguate Mine was investigated in 2010 for contamination of soil, surface water, and ground water (EPA, 2012a). The Jackpile-Paguate site was placed on the National Priority List (NPL) in December 2013 (Federal Register, FR, 75475, December 12, 2013).

Objective 6: Public Health Surveillance

Action Plan Tasks:

1) Recruit volunteers for study particularly residents with private well and those living near legacy uranium mines;
2) Coordinate with local physicians to provide training on uranium exposure, communication, and outreach planning; and
3) Provide twice-yearly public updates on public health surveillance.

Regulatory legislation and programs. A variety of federal legislation that addresses potential exposure to COCs in air, soil, water, and food includes the CAA, CWA, SDWA, TSCA, RCRA, CERCLA, and the Federal Food, Drug, and Cosmetic Act. Through these federal legislation the government sets requirements and standards that seek to minimize contact with COCs in the everyday environment. The primary state agencies, the New Mexico Department of Health (DOH) and NMED have the overall mission to protect public through surveillance and testing. Western US states (AZ, CO, NM, UT, and WY) have in common areas with large and long histories of mining especially uranium mining (Colorado

Department of Public Health and Environment [CO DPHE], Rocky Mountain Biomonitoring Consortium, 2014). Some areas of the Rocky Mountain States show elevated levels of biomonitoring indicators of heavy metal exposure when compared to the rest of the nation (e.g. uranium in urine).

Technical factors and considerations. NM DOH recruited volunteers in the Grants District area during May and June of 2010 as part of a pubic health surveillance for uranium exposure. An earlier study of the overall New Mexico population indicated the average uranium in urine concentration to be 0.030 micrograms per liter or ug/L (CO DPHE, 2014). The national average for uranium in human urine is 0.005 ug/L and comparison to this value indicates New Mexico's levels are six times higher than the national average. In 2010, the NM DOH selected the Grants District area to test for exposure to uranium because the area is rich in uranium deposits and parts of the area are contaminated due to past mining and milling operations. An exposure survey, drinking water sample analysis, and urine testing for uranium were conducted on 100 people from the Grants/Milan area and Laguna Pueblo (NM DOH, 2011). The average uranium concentration in a total of 91 drinking water samples was 0.006 ug/L and three samples exceeded the 0.030 mg/L standard.

The average urine uranium concentration was 0.045 ug/L for the group of 99 samples. The 0.045 ug/L average value is higher than the national average (0.005 ug/L) by a factor of nine. Volunteers with uranium levels greater than 0.080 ug/L were identified as those people with a recent or ongoing exposure of uranium (29 participants). Using information obtained from the exposure survey, NM DOH attempted to identify the different sources of exposure to uranium in the 29 participants' environment. Participants were asked about eating local livestock and fruits and vegetables grown at home with water from wells elevated in uranium during the last three days. Very few participants had eaten local livestock or home grown fruits/vegetables within the last three days. When asked about whether participants had been recreating outdoors within the last 30 days, approximately half (52%) of the 29 participants responded that they had been, running, hiking, and/or biking in Cibola and/or McKinley County within that time. When the 29 participants were asked about gardening and collecting local plants, approximately 41% responded 'yes" to this activity.

Financial cost. The New Mexico Legislature allocated funding for the 2010 biomonitoring study during the 2007 legislative session, which paid for the analyses performed by the State Laboratories Division. At an estimated cost of approximately $10 each to test for uranium in urine and water ($20 total), the estimated cost for sample analysis in the biomonitoring study is $1,900. The estimated cost to conduct the outreach, education, sample collection, data interpretation, and report writing is unknown. It does not appear that there are financial issues and constraints associated with the 2011 biomonitoring study, and similar studies could be performed in the future depending on funding sources and allocations.

Overall evaluation. Task 1 and 2 were implemented and completed during 2010-2011 according to the implementation time line. Task 3 includes the publically accessible 2011 biomonitoring report entitled, "*Grants Mineral Belt Uranium Biomonitoring Project Summary*," posted on the New Mexico Environmental Health Public Tracking website (nmtracking.org).

Chapter 6: Findings and Discussion

Findings

In Chapter 5 we evaluated the work required for completion of the Six Major Objectives and their respective Action Plan Tasks. The evaluation determined: 1) the degree of completion; 2) the applicable environmental statutes; 3) the regulatory issues; 4) the technical complexities; and 5) the financial cost for accomplishment of the Six Objectives. Table 5 presents the status and summary of 5YPlan Six Objectives Action Plan Tasks during 2010-2014. The EPA 5YPlan accomplishments and progress during 2010-2014 toward completion of its Six Objectives indicates that *Jackpile Mine* and *Biomonitoring* (objectives 5 and 6, respectively) were achieved; *mill sites* and *residential structures* (objectives 3 and 4, respectively) show accomplishments and continuing work; and objectives 1 and 2 show some progress but these two objectives were not fully achieved.

For Objective 1 (*ground water)* there was progress and accomplishments related to Tasks 1, 3, 4, and 5 during 2010-2014. *Regional ground water study* (task 2) was not completed but there were focused investigations of ground water quality in parts of the Ambrosia Lake area (NMED, 2010; Langman et al., 2012; DOE, 2014c; & EPA, 2014b). For Objective 2 Tasks 1 and 2, the prioritization for site assessment and screening reports were not fully completed for all mines. Since Tasks 1 and 2 were not completed, *plan investigations at priority sites* (task 3) and *regional ground water study and phased investigations* (tasks 4 and 5, respectively) could not be completed. State of NM draft guidance documents for uranium mine assessment and cleanup were developed to address Task 6 (*characterization protocol*). Twice a year updates on the status of the 5YPlan (task 7) is ongoing through updates and occasionally a public meeting in the Grants, NM area.

For Objective 3 (*mills*) all four Tasks were achieved during 2010-2014 because the DOE is the responsible federal agency in charge of monitoring and long-term management at the two DOE sites.

For Objective 4 (*structures*) Tasks 1-3 were completed during 2010-2014, and further assessment and remediation of residential structures will be ongoing during 2015-2019. The evaluation did not determine if there were any significant regulatory, technical, or financial issues related to Objective 4. Pueblo communities like the Laguna and Acoma are sensitive and protective about many parts of their culture and community. EPA will have to continue working on a government-to-government basis with the Pueblos of Laguna and Acoma during 2015-2019 to further work on Objective 4. Residential structure assessments require that EPA and their contractors work closely with homeowners to identify the hazardous areas and amount of any proposed structure mitigations and/or soil removals where necessary.

For Objective 5 (*Jackpile Mine*) all four Tasks were achieved during 2010-2014. The Jackpile-Paguate Mine was placed on the EPA National Priority List (NPL) in late 2013 as a high priority site in the CERCLA Superfund Program. Work on the Jackpile-Paguate Mine will follow the CERCLA Process (Figure 3) and the Remedial Investigation (RI) and Feasibility Study (FS) should begin during 2015-2019. No schedule is available on when the RI/FS would be completed and a Record of Decision (ROD) would decide the types and levels of cleanup for the site. EPA-Atlantic Richfield Company (ARCO) negotiations regarding an Agreement On Consent (AOC) for the RI/FS may soon determine when a draft work plan and schedule would be available for review.

For Objective 6 (*biomonitoring*) all three Tasks were achieved during 2010-2014. The NM Department of Health (DOH) conducted a biomonitoring study in the Grants District area funded by the state through the testing of volunteer urine samples for uranium (NM DOH, 2011). The study determined based on a group of 99 samples that the average level of uranium in urine was 0.045 ug/L, which is higher than the national average level of uranium in human urine (0.005 ug/L). The potential sources of uranium exposure among the group of volunteers were not identified and any detrimental health effects from elevated levels of uranium in urine were not determined in the study.

Discussion

The discussion is organized under four major headings: Regulatory Practice; Uncertainties; Financial Burden; and Health Impacts.

Regulatory practice. The regulatory analysis indicated that there is no single federal or state regulation that requires a regional ground water quality study to check water supplies for contamination from legacy uranium operations. Some sites have ongoing monitoring programs required by UMTRCA, CERCLA, SDWA, and the 20.6.2 NMAC Discharge Permit (DP) program (*e.g.*, Bluewater, Homestake and Rio Algom sites). Some areas like lower San Mateo Creek north of Homestake and immediately down gradient off site to the south and east from the Bluewater facility do not have a properly designed monitoring network as required by a federal or state regulation (NMED, 2010). Ground water investigations have to rely upon private wells to provide data in some locations, but large areas have no monitoring or private wells resulting in data gaps that hinder completion of a regional ground water contamination study (objective 1).

The regulatory analysis indicated that there is no single federal legislation that addresses the requirements for uranium mine waste assessment and cleanup (Objective 2). Even though uranium mine waste can be hazardous, it is specifically exempted from regulation as a hazardous waste under RCRA through the Bevill Amendment (51 FR 24496, July 3, 1986). EPA has authority under CERCLA to request and force mine PRPs to conduct assessments and cleanup under land use conditions based on risk to human health and the environment. Unfortunately, the remote location for many of the mines on private land results in very low levels of potential exposure and risk which limits the EPA's authority under CERCLA to require PRPs to assess and remediate sites with contamination above background or exceeding standards.

Under 20.6.2 NMAC the state has the stronger regulatory authority to require mine owners to assess ground water for contamination as it relates to their operations that discharged contaminants or had the potential to discharge contaminants to the environment (NMAC 20.6.2000). NMAC 20.6.4106 addresses "abatement" and the requirement for an investigation into "*the vertical and horizontal extent and magnitude of vadose-zone and ground-water contamination*," for the "site." This requirement should include the extent of former mine water discharges to now dry surface arroyos and drainages in the SMC Basin. If wet mine operators do not voluntarily participate in a regional ground water study, then state authority under the 20.6.2 NMAC is appropriate to force operators to assess/cleanup the impacts of their specific mine dewatering and discharge operations. The enforcement process is hampered by the lack of attribution evidence that fingerprints and links the contamination back to the original source.

NMED does not have funding to conduct assessments that would provide the scientific evidence linking legacy sites to ground water contamination (Martin, 2007). Without data NMED says it cannot successfully start the enforcement process with PRPs, because PRPs can challenge and defeat state enforcement actions if there is a lack of scientific data (Martin, 2007). The scientific data that is needed under the 5YPlan enforcement strategy is the "attribution" evidence for the origin of contamination in ground water from legacy uranium operations. Attribution for the contamination also assigns the liability for the resources to conduct further assessment, mitigation, and long-term monitoring of impacted ground water areas. The historical water quality collected and documented by the State during the 1980s when mines were actively discharging contaminants is scientific attribution evidence that could be used to start the enforcement process (Gallaher & Cary, 1986).

Acquisition of new data that more convincingly links contamination to mine operations is warranted under the 5YPlan, but it appears the State has the regulatory jurisdiction and adequate data to begin the enforcement process now. Although the State has cited the lack of funding to collect attribution data as the barrier to enforcement under the "polluter pays" principle of CERCLA, it appears the State may not be fully committed to and planning enforcement until later in the 5YPlan cycle. Interestingly, NM returned primacy for regulation of uranium mills to the NRC in 1986 in order to save money during a state budget shortfall period, and to end the state-industry regulatory battle over how dangerous uranium mill tailings are and how much money should be spent to clean them up (Hester, 1986).

The EPA 5YPlan has not specified or resolved the issue of the regulatory cleanup standard for soils and waste rock at legacy uranium mines. The cleanup level for legacy uranium mines is a controversial topic that needs to be resolved in order to move forward with the assessment and cleanup mines (objective 2). It is likely that the different land managers and agencies will decide that no one uniform cleanup standard will work for all sites, but sites with higher cleanup standards will have to use institutional controls and long-term stewardship to mitigate any risks to the environment and human health. The state of NM has developed draft guidance for legacy and new uranium mine assessment and cleanup (EMNRD, 2014a & 2014b). Unfortunately, there has been no industry, EPA, or public review and comment on the draft guidance documents. As described above, the lower the soil radium cleanup standard, the more material that is generated during the remedial action that must be contained in an engineered disposal cell on site, or trucked off site to a central disposal facility that could be many miles away. On site disposal cells containing radioactive mine waste from cleanup actions will have to be monitored and maintained, and some sites may need land use restrictions to control human access and potential exposure to hazardous contaminants.

The regulatory activities for the Jackpile-Paguate Mine will involve a sequence of iterative steps based on the Remedial Phase of the CERCLA Process (see Figure 3). The RI/FS will guide and require the acquisition of data that will be used to develop remedial alternatives for the site. With such a large and complex site both technically and socially, the journey to remediate the Jackpile-Paguate Mine will be long and resource intensive. No information was available on the regulatory status of the Jackpile-Paguate Mine, and whether any negotiations with the PRP are leading to an Agreement on Consent (AOC) and a scope of work/schedule for the RI/FS.

Uncertainties. The major areas of uncertainty pertain to the extent and degree of ground water contamination at the site and regional level, and the extent and degree of surface contamination at and adjacent to mine sites. The nature and extent of ground water contamination and the long-term threat it presents to the water users of the SMC Basin are largely unknown. EPA acknowledged the lack of a regional ground water monitoring network in the Grants District area in 1975 (EPA, 1975). In 2014 there is still an inadequate number of monitoring wells in the proper locations (gaps) to support a regional ground water investigation although some local areas and sites have monitoring well networks (*e.g.*, Homestake and Bluewater). The primary technical challenge to accomplishing a regional hydrologic and geochemical investigation of contaminant flow and transport in ground water (objective 1, task 2) is that no implementation plan for a comprehensive regional ground water investigation has been developed. A ground water study implementation plan should utilize existing site monitoring wells, private wells where appropriate, and new wells in key data gap locations to form a more comprehensive regional ground water monitoring network. EPA's ground water investigation mentioned in the 2014 5YPlan Update should provide new information to support an implementation plan to satisfy a regional hydrologic and geochemical investigation of contaminant flow and transport in ground water (objective 1 task 2) that can be put into effect during 2015-2019 (EPA, 2014b).

The systematic assessment, prioritization, enforcement, cleanup, and closure of legacy uranium mines (objective 2 task 5) overlaps with a regional hydrologic and geochemical investigation of contaminant flow and transport in ground water (objective 1 task 2). One additional area of uncertainty related to the ground water investigation tasks associated with uranium mine assessment and cleanup pertains to the wet mines that re-circulated water through the dewatered mine formations to dissolve uranium for later removal. Excavation and mine dewatering exposed the ore zone to air causing mineral oxidation and dissolution. The dewatered aquifer was subjected to recirculation and re-saturation, which have altered the hydraulic and geochemical nature of the ground water system to an unknown extent. More information is needed to characterize the impact to the deeper ground water system.

There is no way to know the full scope of uranium mine surface radioactivity conditions, the extent of cleanup required, and obtain reliable cost estimates without more site specific gamma radiation survey and laboratory sample analysis. The technical uncertainty is compounded by the lack of regulatory agreement on a mine soil cleanup level based on Ra-226 concentrations. More site specific gamma survey and laboratory sample data for each mine would enable the calculation of potential waste volumes at various levels of cleanup and their relative estimated costs to reclaim or remediate the waste. As noted above uranium mines that have impacted tens of acres on the surface with elevated radioactive soil and waste rock could potentially require management of thousands of cubic yards of radioactive material on site or off site.

The main technical issue for the contaminant assessment, cleanup and long-term management at former uranium milling sites (objective 3) is the need for DOE to determine the extent and nature of the "Bluewater derived uranium and mill-related constituents" that are migrating beyond the site boundary. The DOE identified a 2.5-mile area without monitoring wells completed in the San Andres Aquifer between the Bluewater and Homestake sites (DOE, 2014c). The DOE status report also determined that the northwestern most well in the Milan municipal water supply system appears to be impacted by "mill-related contaminants" although the level of uranium remains below the drinking water standard (0.030 mg/L) it is slightly above the background level of 0.010 mg/L (DOE, 2014c). Clearly more environmental work is necessary to define the nature and extent of the contaminant plume from the Bluewater site as it continues to move in the San Andres

Aquifer. It is also necessary to determine if off site pumping conditions in the San Andres Aquifer exacerbate the movement of Bluewater site contaminants. The potential for Bluewater contamination to impact water rights in the San Andres Aquifer are unknown at this time.

One other aspect of uncertainty that was not addressed in the 5YPlan is how the Homestake mill site remediation project fits into the Plan's six objectives. This UMTRCA and CERCLA site is a source of ground water contamination and a substantial level of effort is being expended to cleanup contaminant releases in this part of the lower SMC Basin. The development of a ground water study implementation plan should consider how the Homestake site factors into and contributes to the *Assessment of water sources for contamination;* and *Contaminant assessment, cleanup and long-term management of former uranium milling sites* (objectives 1 and 3, respectively)

Financial burden. The responsibility for the environmental damage caused by mining operations that largely ended before modern environmental regulatory programs were established creates the difficult situation of who can rightfully be held accountable for the cleanup (Buck & Gerard, 2001). Many mine sites are so old that no financially viable party exists today that can be held liable for the cleanup costs so the federal government and ultimately the taxpayer bear the cost. The Mineral Policy Center estimated the cost to cleanup abandoned mine features across 32 western states ranged from $32 to $72 billion, and the average cost to address ground water contamination at each site ranged from $7.5 to $12.5 million (Lyon, Hilliard, & Bethell, 1993, 9). This evaluation developed a conservative estimated cost range of $249 million to $633 million to remediate 96 legacy uranium mine sites. A reliable estimated cost range per mine site is not possible without more site specific data. There appears to be no 5YPlan strategy or planning to incrementally obtain funding in the estimated range of $250-$630 million to address legacy uranium mines in the Grants District.

The 5YPlan strategy to have the PRP assess and remediate their sites will not cover all the legacy sites in the Grants District. Many of the former mine operators as companies no longer exist so there is not a viable, financially solvent PRP worth pursuing under a regulatory enforcement strategy. For some legacy sites, especially those small mines from the 1950-1970 period, there is likely not a viable PRP anymore. Enforcement is a time-consuming, protracted, and some times inefficient effort requiring staff and resources that may not always result in a monetary award or environmental participation by the PRP. There is evidence to suggest that some enforcement efforts are not efficient use of federal and state resources, and it is easier to seek funding from non-PRP sources, i.e., public funds (Buck & Gerard, 2001). An enforcement strategy should include the option of Supplemental Environmental Projects (SEPs) instead of non-compliance monetary penalties such that the PRP could voluntarily or involuntarily agree to conduct or fund assessments and monitoring as a more constructive alternative to fines (Esthworty, 2014).

Even though a cost estimate to remediate large areas of ground water contamination in the SMC Basin was not developed in the evaluation, the Bluewater, Homestake, UNC-Phillips, and Rio Algom site efforts to remediate ground water quality to regulatory standards are examples to reference for cost and performance information associated with the 5YPlan *regional ground water study* (objective 1). However, no information in the 5YPlan Updates mentioned how potential funding alternatives might obtain resources for any potential long-term ground water remediation outside the jurisdiction of UMTRCA other than the "attribution-enforcement-PRP pays" concept using state regulatory authority 20.6.2 NMAC.

This study has developed a mid-range cost estimate of $86,000 per new well that includes the construction, aquifer testing, and one time sampling of the well. Using EPA's 1997 Ambient Ground Water Quality Monitoring Cost Analysis values in Appendix C (EPA, 1997); the cost per foot for bedrock well construction would be approximately $103 per foot in 2014 (McMahan, 2014, inflationdata.com, 2015). DOE installed 10 new monitoring wells at Bluewater, and completed a hydrogelogic assessment report during 2010-2014. Although the 2014 DOE status report identified a large area with no wells between Bluewater and Homestake, no recommendations or work plan was provided that included a cost estimate for a set of proposed investigative activities (DOE, 2014c).

Health impacts. The biomonitoring results for urine uranium levels in the NM general population and the group of volunteer participants from Grants/Milan and the Laguna Pueblo could be cause for concern in several ways. First, the biomonitoring results indicate that as a state, NM residents are regularly exposed to elevated levels of uranium in their environment. Second, NM residents in the Grants/Milan area and Laguna Pueblo appear to draw their exposure from activities related to the outdoors. This means that there are native sources of uranium in the Grants/Milan-Laguna environment that can come into contact with humans when they are outdoors. Third, the health impacts from exposure to natural and anthropogenic uranium in the Grants/Milan-Laguna area are unknown because very little health study work has been done. And fourth, the presence and controversy of uranium as both a potential economic resource and heavy metal with cancer-causing radiation may discourage some tourism and development until legacy cleanup is resolved. Biomonitoring information may be perceived as negative. Businesses and political leadership at the local, county, and state level may choose to down play the value and results of biomonitoring studies since they may portray a negative image of NM. The 2011 NM DOH biomonitoring report did not recommend any further biomonitoring study for the Grants/Milan-Laguna areas.

One of the original reasons behind the development and execution of the 5YPlan was to identify and mitigate human health impacts in a timely manner. If one of the positive outcomes of completing the 5YPlan is to create a safer more-healthier environment, then biomonitoring would be one method to help inform and guide the completion of that goal. Worker and public health when it comes to the uranium industry is controversial and some studies show a direct cause-and-effect relationship between uranium exposure and health. Where evidence of exposure is lacking to establish clear relationships to health impacts, the emotional stress for residents is always present when they live and work in the Grants District close to sources of radioactive materials that need to be properly assessed and cleaned up. According to an article in the Cibola Beacon, a 2015 legislative bill proposes to create a community health fund to study the impacts that uranium mining pollution poses to public health (Boyett, 2015). That bill was never heard. Supporters of the community health fund bill stated a comprehensive health study of the Grants communities has never been conducted and it is important to determine if uranium plays a factor in public health around uranium mining areas (Boyett, 2015).

The Pueblo of Laguna assumed the lead responsibility for the proper reclamation of the Jackpile Mine, but the EPA Compliance Assessment for the mine indicates their reclamation does not meet environmental compliance standards (EPA, 2012a). The placement of the Jackpile-Paguate Mine on the NPL could result in Superfund Site stigmatization and the perception that the site is polluted, the land is contaminated, and people should be wary of the human health risk until cleanup is achieved. EPA and other federal agencies will have to work closely, government to government, with the Pueblo of Laguna and Atlantic Richfield Company to develop the remedial path forward for the site. The Laguna are culturally and socially tied to the land surrounding the Jackpile Mine and they cannot simply relocate to other lands in the area (Jacobs, 2004). The Jackpile Mine has permanently impacted the once protected land, language, and social fabric of the Laguna since so many members worked at the mine and were exposed to heavy metals and radioactivity. Biomonitoring of the members of the Laguna Pueblo is worth considering as a tool to determine if there are existing health impacts and how those impacts would be mitigated by the remedial actions to be implemented at the mine.

Chapter 7: Recommendations

Develop Implementation Plan for Ground Water Study

The 5YPlan regional ground water study objective (#1) involves a large and hydrogeologically complex land area, i.e., the San Mateo Creek (SMC) Basin. There are parts of the study area where there are many monitoring wells and data that provide a reliable understanding of the contaminant hydrogeology from legacy uranium impacts at that location. There are also areas where there are data gaps due to the lack of wells. An implementation plan needs to be developed to focus the limited resources under the 5YPlan so the areas with data gaps are addressed in a systematic and prioritized fashion during the next phase of work under Objective 1. An implementation plan would include not only the data to be collected, the types of laboratory analyses, and samples locations, but also a description and schedule of how the investigation will proceed according to a master schedule and the products that will be developed to assess ground water contamination. It may be appropriate to design an implementation plan that divides the SMC Basin study area into smaller units that make phased investigations easier to manage. An implementation plan should also identify experts who can be tasked to help interpret complex data and understanding of contaminant fate and transport.

Enforce Ground Water Protection Regulations at Legacy Uranium Sites

The NM Water Quality Act (WQA) created the requirement for the management of water quality in the state. The WQA established the Water Quality Control Commission (WQCC) as the state water pollution control agency. It also included various components such as water quality standards and a discharge permit program for surface and ground water. The WQCC assigned the responsibility for protection of NM's ground water resources from discharges at legacy sites to NMED. The Mining Environmental Compliance Section of NMED manages the Discharge Permit (DP) program for the enforcement of assessment, abatement, and closure activities at legacy uranium sites. The WQCC and NMED should fully enforce ground water protection regulations to support the EPA 5YPlan cleanup of mines (objective #2).

Enforcement of NM ground water regulations would require support of NMED leadership with the WQCC performing an oversight role. Uranium mine soil and waste rock cleanup levels would need to be evaluated and finalized among the agencies, mining industry, and public since it is an important technical criteria for site compliance and close out of the Discharge Permit (DP). NMED should notify mine owners, landowners, other agencies, tribal nations, and the public that it is going to fully execute the 20.6.2 NMAC regulations (20.6.2000), and every legacy uranium site is required to comply with the DP program for assessment, abatement, and closeout of their site. As stated by NMED in their 2014 Clean Water Act report, state enforcement is based on three key approaches: 1) voluntary compliance; 2) Notices of Violations and issuance of penalties to compel compliance; and 3) a civil lawsuit to legally force compliance. Since enforcement is contingent on limited state resources, NMED would require adequate resources and staff to execute and sustain a full enforcement program for legacy uranium sites. If there are insufficient resources to support the enforcement program or the process is taking too long to bring sites into compliance, the state legislature should consider adding a provision for citizen enforcement of state ground water protection statutes. Citizen enforcement of state statutes could help effectuate cleanup by allowing citizens and nongovernmental organizations to file suit and force remediation activities in a manner similar to the citizen suit provisions under the federal environmental protections acts, e.g., Clean Air and Clean Water Acts.

If NMED were to implement full enforcement of NM regulations at legacy uranium sites through the DP program requirements, it would off set the need to acquire convincing chemical data to demonstrate attribution for the contamination to start the enforcement process. Legacy uranium site owners and not NMED are required to demonstrate that their operations and/or site materials did not degrade or have the potential to degrade ground water quality beyond state standards. The state collected convincing technical data in the 1980s when legacy mines and mills were actively discharging contaminants to surface water and ground water systems so there is technical data and documentation already available to start the enforcement process (Gallaher & Cary, 1986). It is the burden and responsibility of legacy site owners to acquire the data following DP requirements, and demonstrate whether there was a contaminant release or a potential to release contaminants from their sites. If legacy sites released contaminants beyond state standard and there is a potential to degrade ground water quality, then the release will have to be abated until it complies with standards. NMED would work with the WQCC; the NM Energy, Minerals, and Natural Resources Department; Bureau of Land Management, and EPA to coordinate enforcement notices and the regulatory actions required under the DP program.

Enhance and Strengthen Public Participation in 5YPlan Activities

More interaction with the public in the 5YPlan through informational meetings and designed participation events would help raise public understanding and support for the Plan. NM emphasizes public involvement as an important aspect of programs to protect ground water quality (NM WQCC, 2011, XIV). Land owners, various agencies, tribal nations, businesses, and residents in the Grants District would be invited to attend meetings and participate in designed events like an education or recommendation workshop. The EPA 5YPlan work during 2015-2019 should include a public involvement plan (PIP) that provides informational updates, and includes some events to obtain feedback and/or recommendations from the public on a issue or proposed solution. Agency public relations staff and meeting facilitators should survey their stakeholders about the environmental issues at hand before developing a PIP in order to gauge public concerns and knowledge about legacy cleanup issues. Based on initial survey responses and other factors, public meetings and workshops could be designed to be effective events that are valued by the public (and agencies) as worthwhile and constructive. Credible public involvement includes documentation of events and input such that the public can track how their recommendations and/or feedback was utilized by the agency in an issue related to the 5YPlan.

Another component that is an integral part of a PIP and one that would promote public education and involvement includes a project website(s) of information specific to the 5YPlan objectives and activities. Projects such as the 5YPlan should have a comprehensive website of information, data reports, maps, and links so the public can access data and read documents for themselves. A good website of project information is one way to educate and to demonstrate openness, transparency, and accountability for work under the 5YPlan. A good website with links to the various agencies that support the 5YPlan may also enhance collaboration during the next phase of work.

Utilize University Expertise and Resources

NM universities are fortunate to have subject matter experts over a wide range of topics related to the 5YPlan, and they should be utilized to help advance Plan activities where appropriate. Universities are generally viewed as credible, politically neutral institutions that can provide specialized assistance on projects like the 5YPlan. University experts in the areas of geology, hydrology, contaminant chemistry, engineering, health physics, anthropology, and law should be more involved in the 5YPlan activities and outcome. During the period of peak uranium mining and milling in the Grants District (1960s-1980s), NM universities were active through student work and assessment projects. Involvement of NM universities in the 5YPlan creates the opportunities for students to learn and participate in an important project for the citizens and the state. Universities can also help fill gaps in resources and staff, and perhaps take on some specialized tasks. Universities have specialized lab equipment and capabilities that should be utilized for sample analysis and assessments using data bases, geographical information systems (GIS), and computer modeling.

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Figures

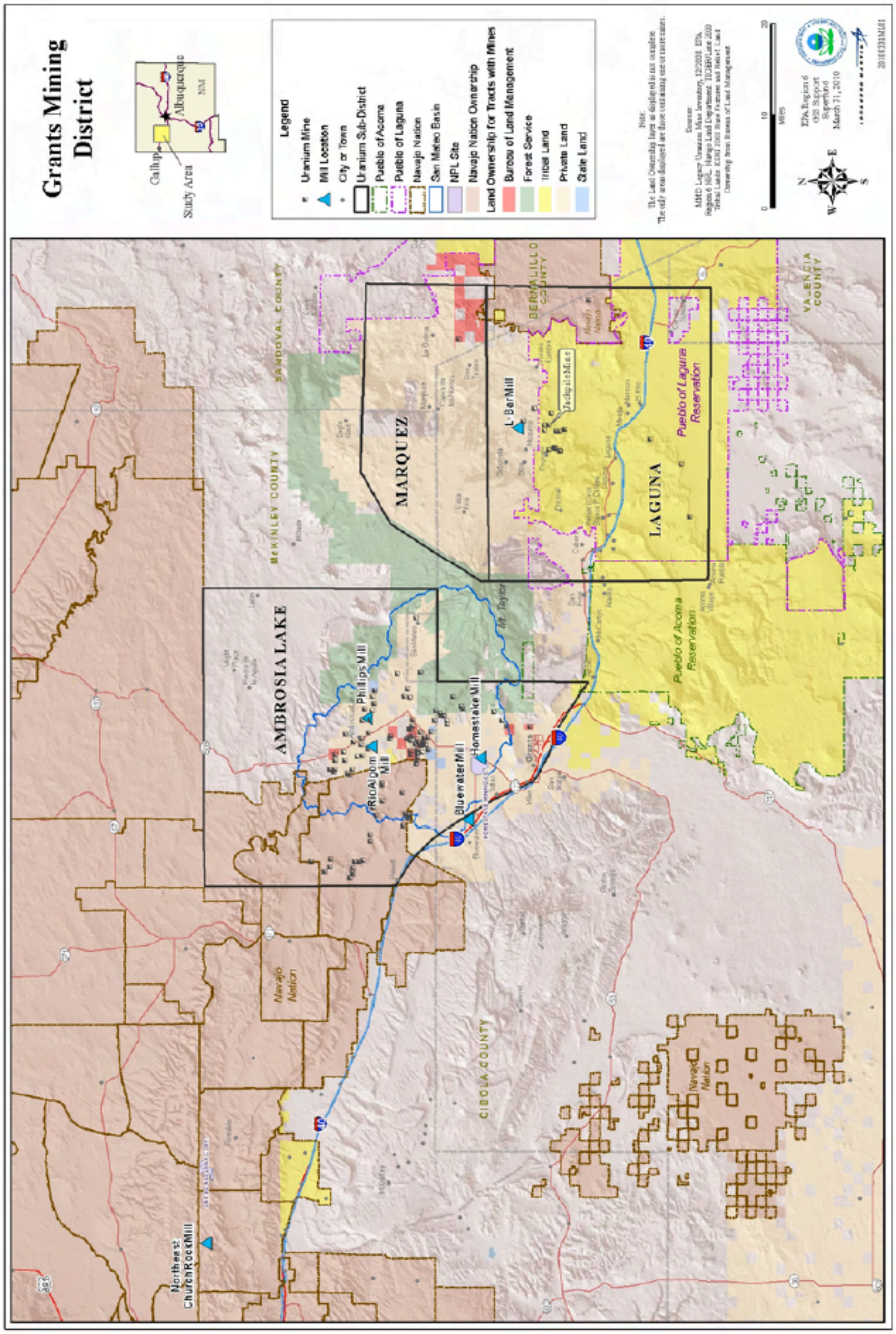
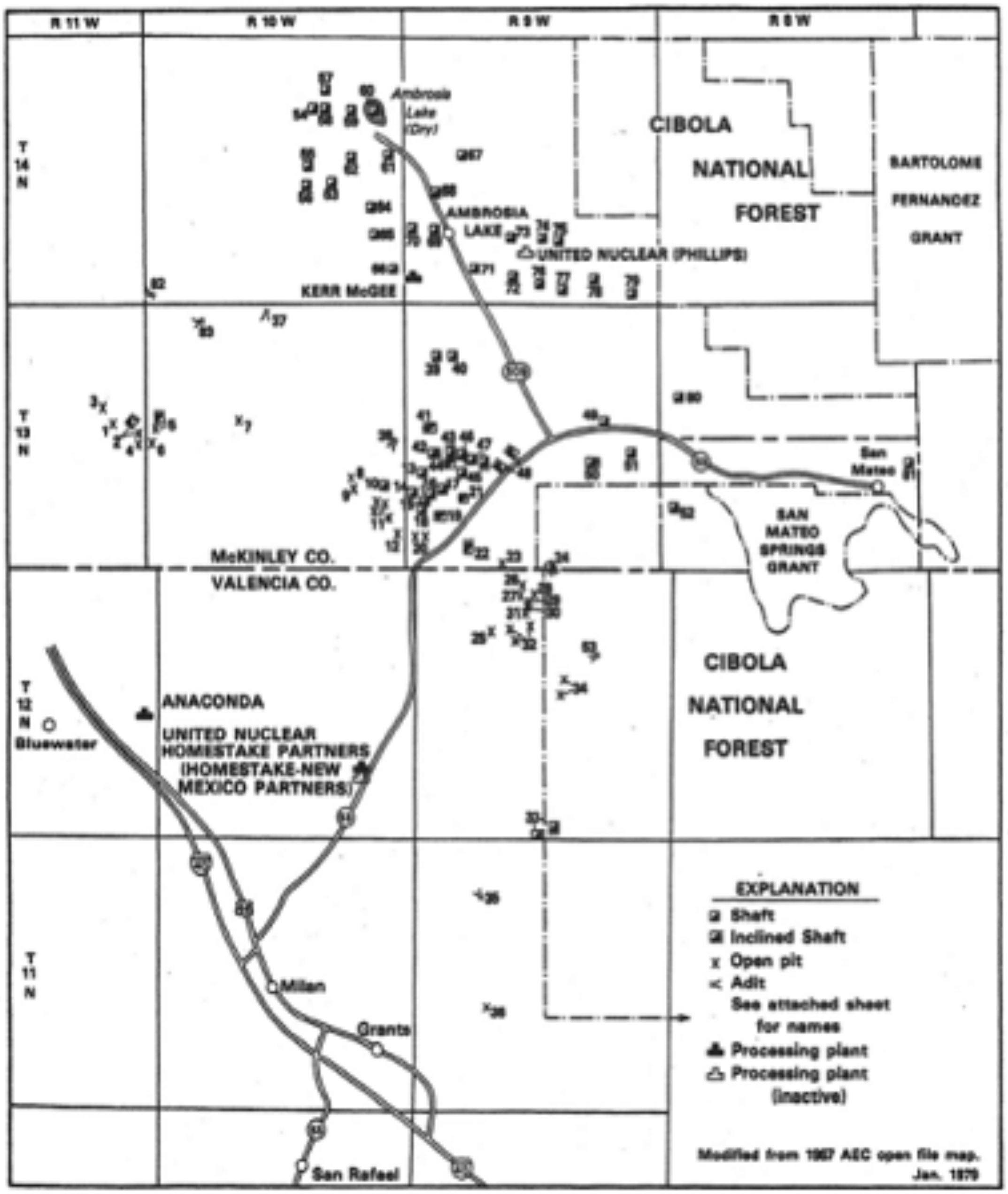


Figure 1. **Location map of the Grants Mining District in northwest New Mexico (after EPA, 2010).**



Mine Location Map, Ambrosia—Bluewater Area, New Mexico

Grand Junction Office
U.S. Department of Energy

FIGURE 11

***Figure 2*. Location map of the uranium mines and mills in the Ambrosia Lake-Bluewater area, 1979 (after Department of Energy, 1979).**

TABLE 4

INDEX OF URANIUM MINES AMBROSIA—BLUEWATER AREA, NEW MEXICO

Mines In Todilito Limestone

1. SW¼ 13-13-11
2. SE¼ 13-13-11 (DOE Lease)
3. S½ NW¼ 13-13-11 (DOE Lease)
4. NE½ 24-13-11
5. SW¼ 18-13-10
6. 19-13-10
7. Red Point
8. 23-13-10
9. NE¼ 26-13-10
10. Section 25 shaft
11. Section 25 pits
12. Rimrock
13. Hope
14. White Cap
15. Barbara J No. 2 (Dalco)
16. Barbara J No. 1
17. Barbara J No. 3
18. Roundy Lease
19. Flat Top
20. Section 31
21. Faith
22. Moe No. 4
23. Charlotte
24. Vallejo
25. Last Chance
26. Red Bluff 3, 5 & 9
27. Red Bluff 2 & 4
28. Christmas Day 1
29. Blackhawk, Bunny
30. UDC 5
31. Red Bluff 7, 8 & 10
32. Section 9
33. F-33
34. La Jara
35. Lone Pine 3
36. Cedar & Falcon

Mines In Morrison Formation—Poison Canyon Area

37. Dakota (Pat)
38. Blue Peak
39. Isabella
40. Spencer
41. Gossett
42. Poison Canyon
43. Beacon Hill
44. Davenport
45. Mesa Top
46. Malpais
47. Dog and Flea
48. Doris
49. Hogan
50. Marguez
51. Rialto
52. San Mateo
53. Taffy

Mines In Morrison Formation—Ambrosia Lake Area

54. Section 10
55. Section 15
56. Section 22
57. Mary No. 1
58. Dysart No. 1
59. Dysart No. 2
60. Section 12
61. Section 13
62. Buckey
63. Section 23
64. Section 24
65. Section 25
66. Section 36
67. Section 17
68. Section 19
69. Section 30
70. Section 30 West
71. Section 32
72. Section 33
73. Anne Lee
74. Section 27
75. Section 27 No. 2
76. Billy John
77. Sandstone
78. Elizabeth
79. Cliffside
80. Johnny M
81. Mt. Taylor (under devel.)

Mines In Dakota Sandstone

82. Silver Spur
83. 5-13-10

***Figure 2 continued*. Location map of the uranium mines and mills in the Ambrosia Lake-Bluewater area, 1979 (after Department of Energy, 1979).**

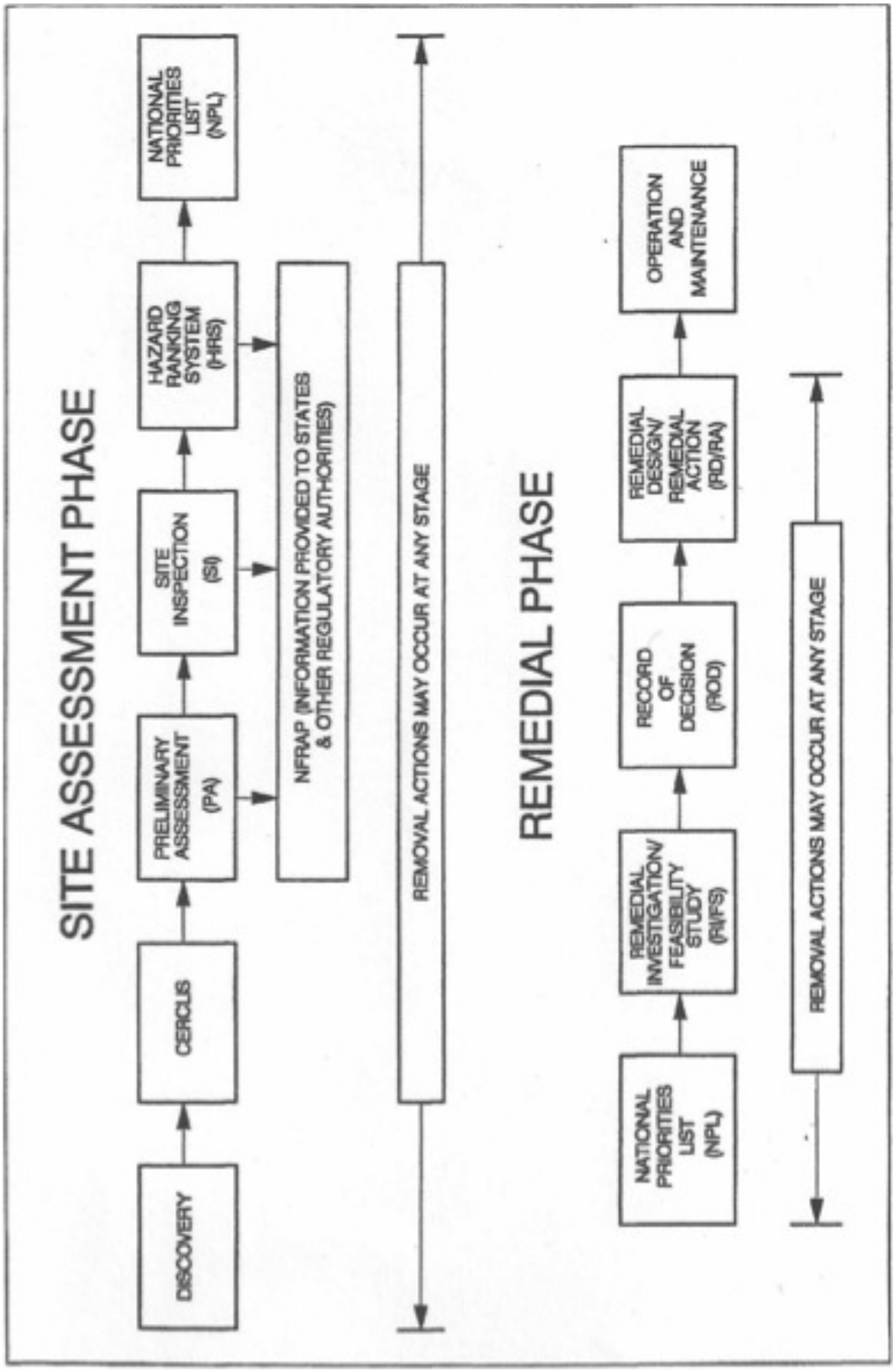


***Figure 3*. Illustration of the CERCLA-Superfund assessment and remediation process (after EPA, 1991).**

Tables

Table 1. ***Six major objectives and action plan tasks in the 2010 EPA Five-Year Plan for the assessment and cleanup of legacy uranium impacts, Grants Mining District, New Mexico (after EPA, 2010).***

Objective	Responsible agencies & programs	Action Plan Tasks (Summarized)
ONE (1), GROUND WATER: Study & monitor ground water supply for contamination	EPA, NMED, NRC, DOE; Superfund; UMTRCA; NMED Superfund, MECs-DP	1. Continue ongoing EPA/NMED sampling of area water supplies, with interpretation of analytical results sent to well owners. Provide technical assistance & recommendations to owners of impacted private wells to reduce exposure to chemicals above federal & state standards. 2. Initiate regional hydrogeologic-geochemical studies to evaluate & model potential anthropogenic & natural contaminant pathways for persistent potential threats to drinking water supplies. 3. Evaluate public water supply wells potentially at risk from contamination originating from legacy uranium sites. 4. DOE has provided all existing data from UMTRCA mill sites, & continues to work with the other agencies and NMED to provide site access, split samples, & has offered to expand the suite of analytes as well as installing some new wells to improve the understanding of the possible site impacts to the ground water in the immediate area of the Office of Legacy Management managed mill sites. 5. EPA will issue a twice-yearly update to the public on progress of the assessment of water supply sources objective.
TWO (2), MINES: Assess & remediate legacy uranium mine impacted areas	NMED, EMNRD-MMD, BLM, USFS, EPA; NMWQA, NMMA, 36 CFR 228, 43 CFR 3809, CERCLA	1. Review available data on legacy uranium mine sites. Compile historical chemical data into a geodatabase. Prioritize areas of contiguous mine sites for assessment screening in coordination with ongoing NM EMNRD surface reclamation program actions & identify data gaps. 2. Conduct & document site screening assessments on the estimated 96 mine sites by the end of September 2011 to determine site hazards & needs for immediate removal, regulatory enforcement, &/or further site investigation & remedial action. Mitigate threats from sites that pose an immediate & substantial threat to human health & the environment & prioritize sites for remedial actions. 3. Assemble preliminary assessment reports & plan for phased investigation & assessment activities on appropriate sites as prioritized; such investigational phases may include geologic mapping, sediment & surface water sampling, geophysical surveys, & shallow and bedrock aquifer monitor well installations & sampling. 4. Initiate regional hydrologic-geochemical studies (*subtasks a through e not listed here*). 5. Conduct phased investigations & successive site reprioritizations, in coordination with the NM EMNRD surface reclamation program activities; beginning with highest-priority mine sites from the investigations (*subtasks a through f not listed here*). 6. Develop integrated protocols for site characterization & cleanup goals (*subtasks a through c not listed here*). 7. EPA will issue a twice-yearly update to the public on progress of the assessment & cleanup of legacy uranium mines objective.

Table 1 continued. ***Six major objectives and action plan tasks in the 2010 EPA Five-Year Plan for the assessment and cleanup of legacy uranium impacts, Grants Mining District, New Mexico (after EPA, 2010).***

Objective	Responsible agencies & programs	Action Plan Tasks (Summarized)
THREE (3), MILLS: Remediate, close & monitor mill sites	NRC, DOE, EPA, NMED; UMTRCA; CERCLA; NMWQA-DP Program	The proposed action plan is focused on data gaps related to Bluewater & Ambrosia Lake-Phillips mill sites. 1. DOE will continue surveillance & maintenance, ground water monitoring, complete compliance reporting, & public outreach as required by the NRC approved Long Term Surveillance and Maintenance Plans at these sites. 2. DOE has & will continue to work cooperatively with NMED to better understand the ground water quality at UMTRCA mill sites. 3. DOE will install additional monitoring wells at the Ambrosia Lake-Phillips Mill & the Bluewater Mill site. The monitoring well data will help in further determining movement of contaminants & ground water flow in those areas. 4. EPA will issue a twice-yearly update to the public on progress of the assessment, cleanup, & long-term management of former uranium mill sites objective.
FOUR (4), STRUCTURES: Assess & remediate residential structures	EPA Region 6 Prevention & Response Branch	1. Continue to work with residential structure owners to identify contamination issues. 2. Coordinate public outreach in other targeted areas as needed. Iteratively conduct removal radiological assessments & develop mitigation strategies as required. Continue and complete on-ground removal assessments. 3. EPA will issue a twice-yearly update to the public on progress of the assessment & cleanup of contaminated structures objective.
FIVE (5), JACKPILE MINE: Evaluate & propose Jackpile Mine to place on NPL & remediate under CERCLA	Laguna Pueblo, EPA, BIA, IHS, BLM, ATSDR, CERCLA RI/FS Process	1. Continue the consultation process with the Pueblo. The first formal consultation was held with the Pueblo Governor and council members on October 13, 2009. 2. A Memorandum of Understanding signed by the Pueblo of Laguna and the Environmental Protection Agency on June 22, 2010 facilitates consultation, coordination and cooperation in both the removal & site assessment phases/processes of activities & protocols. 3. EPA Superfund Program will conduct a Preliminary Assessment & Site Investigation at the Jackpile Mine. 4. EPA will issue a twice-yearly update to the public on progress of the assessment & investigation at the Jackpile Mine objective.
SIX (6), BIOMONITOR: Conduct voluntary biomonitoring of uranium in Grants area	NM Dept. of Health (DOH), IHS, ATSDR, NMED;	1. Residents in the Grants Mining District will be recruited to participate in the project, which will occur in late spring. Recruitment will be multi-pronged, including: a) Coordinating with EPA to identify individuals who are living in contaminated structures (& willing to participate); b) Through newspaper ads, radio spots, & other means; c) Coordinating with NMED to identify individuals on private wells with elevated uranium levels; d) Residents who live near legacy uranium mines will be encouraged to participate, as will those who are on private wells. 2. Physicians in the area will be notified about the project & ATSDR will work with the lead agency to provide training on uranium exposure & guidelines for care. In addition, a communication & outreach plan will be developed to inform the public of investigation findings & possible appropriate mitigation strategies. 3. EPA will issue a twice-yearly update to the public on the status & results of the public health surveillance objective.

Table 1 continued. ***Six major objectives and action-plan task in the 2010 EPA Five-Year Pan for the assessment and cleanup of legacy uranium impacts, Grants Mining District, New Mexico (after EPA, 2010).***

List of Abbreviations and Acronyms Used in Table 1, Six Major Objectives and Action Plan-Tasks in the 2010 Environmental Protection Agency Five-Year Plan for the Assessment and Cleanup of Legacy Uranium Impacts, Grants Mining District, New Mexico (after EPA, 2010; p. 3 of 3):

ATSDR, Agency for Toxic Substances and Disease Registry
BIA, Bureau of Indian Affairs
BLM, Bureau of Land Management
CERCLA, Comprehensive Environmental Response, Compensation, and Liability Act
CFR, Code of Federal Regulation
DOE, Department of Energy
DP, Discharge Permit
EPA, Environmental Protection Agency
IHS, Indian Health Service
RI/FS, Remedial Investigation/Feasibility Study
MECs, Mining Environmental Compliance section of NMED
MMD, Mining and Minerals Division of EMNRD
NM DOH, New Mexico Department of Health
NM EMNRD, New Mexico Energy, Minerals, and Natural Resources Department
NMED, New Mexico Environment Department
NMMA, New Mexico Mining Act
NMWQA, New Mexico Water Quality Act
NPL, National Priority List
NRC, Nuclear Regulatory Commission
USFS, United States Forest Service
UMTRCA, Uranium Mill Tailings Radiation Control Act.

Table 2. ***Summary of key federal environmental laws and regulatory requirements for federal lands with respect to uranium mining and milling.***

Year	Environmental Law	Summary
1946, 1954, 1959	Atomic Energy Act (AEA) (codified generally as 42 U.S.C. 2012)	AEA encourages the use of atomic energy for both military and commercial applications so as to "provide for the common defense and security and to protect the health and safety of the public." From the beginning, uranium mines and their waste products (overburden, low grade ore, and mine discharge water) were not subject to regulation by the federal government-they were initially the responsibility of the states. AEA created the Atomic Energy Commission (AEC) to license and regulate the production of "source material." Source material is any chemical-physical form of uranium, thorium or any other (radioactive) material as determined by the AEC that has been processed at a mill site including the "by-product materials" such as the leftover tailings (chemically leached, sand-size crushed rock) and concentrated waste fluids.
1948	Federal Water Pollution Control Act (FWPCA) (codified generally as 33 U.S.C. 1251-1387, but amended numerous times)	FWPCA authorized the Public Health Service to work with federal, state and local entities, to prepare comprehensive programs for eliminating or reducing the pollution of the nation's waters and improving the sanitary condition of surface and underground waters. The FWPCA was amended and became the Clean Water Act.
1963	Clean Air Act (CAA) (codified generally as 42 U.S.C. 7401-7671)	CAA authorizes EPA to set mobile source limits, ambient air quality standards, hazardous air pollutant emission standards, standards for new pollution sources, and significant deterioration requirements; to identify areas that do not attain federal ambient air quality standards set under the act; to administer a cap-and-trade program to reduce acid rain; and to phase out substances that deplete the Earth's stratospheric ozone layer.
1970	National Environmental Policy Act (NEPA) (codified generally at 42 U.S.C. 4321-4347)	NEPA declares a national policy which encourages productive and enjoyable harmony between man and his environment; promotes efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; enriches the understanding of ecological systems and natural resources important to the Nation; and establishes a Council on Environmental Quality (CEQ) to advise the president on matters of environmental policy develop and standards.
1972	Clean Water Act (CWA) (codified generally at 33 U.S.C. §§1251-1387)	CWA authorizes the regulation and enforcement of requirements that govern waste discharges into U.S. waters, and financial assistance for wastewater treatment plant construction and improvements. One of the most significant features of the 1972 Act is the creation of a national pollutant discharge elimination system (NPDES) managed by EPA and the states which requires industry and public wastewater treatment facilities (point sources) to obtain a permit before releasing pollutants into surface waters of the U.S. The CWA does not address pollutants that have contaminated ground water.

Table 2 continued. ***Summary of key federal environmental laws and regulatory requirements for federal lands with respect to uranium mining and milling.***

1974	Safe Drinking Water Act (SDWA) (codified generally at 42 U.S.C. 300f-300j-25)	SDWA authorizes EPA to establish primary drinking water standards for contaminants including radionuclides, regulate underground injection disposal practices, and administer a ground water control program.
1974	Energy Reorganization Act (ERA)	ERA established the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), dividing the research and regulatory aspects of nuclear power. Until 1974, the Atomic Energy Commission (AEC), which this act abolished, oversaw both the nuclear weapons program and the development and safety programs for civilian uses of nuclear material. In 1977, the Department of Energy Organization Act established the Department of Energy (DOE) and replaced the ERDA.
1974	Water Resources Development Act (WRDA) (P.L.93-251; 33 U.S.C. §2269, Amended WRDA in 2000, Sec 203)	WRDA is a biennial piece of legislation that is the main vehicle for authorizing water projects to be studied, planned and developed by the U.S. Army Corps of Engineers. Amendments to the WRDA in 2000 created the Tribal Partnership Program in to carry out water resource planning activities with tribes.
1976	Solid Waste Disposal Act (SWDA) and Resource Conservation and Recovery Act (RCRA) (codified generally at 42 U.S.C. 6901-6992k)	The Solid Waste Disposal Act (1965) and Resource Conservation and Recovery Act (RCRA) govern the regulation of solid and hazardous wastes, and corrective actions to address improper waste management practices. The AEA source, special nuclear, and by product material is excluded from RCRA, but it generally does apply to naturally occurring radioactive materials.
1976	Toxic Substances Control Act (TSCA) (codified generally at 42 U.S.C. 6901-6992k; 15 U.S.C. 2601)	TSCA requires regulation of commercial chemicals to reduce risks to human health and the environment. It authorizes EPA to screen existing and new chemicals used in U.S. manufacturing and commerce to identify potentially dangerous products or uses that should be subject to federal control. In1988 Congress amended TSCA by adding Title III—Indoor Radon Abatement (15 U.S.C. 2661 et seq., P.L. 100-551) in order to provide financial and technical assistance to the states that choose to support radon monitoring and control; neither monitoring nor abatement of radon is required by the act.
1977	Surface Mining Control and Reclamation Act (SMCRA) (30 U.S.C. 1201-1328; 91 Stat. 445)	SMCRA regulates surface coal mining activity, requires rehabilitation of abandoned mines in order to protect society and the environment from the adverse effects of mining operations. SMCRA requires uniform standards for coal mines located on federal and state lands, and it is designed It directs owners of coal mines to contribute bonds for land rehabilitation and environmental damages caused by mining activities. The flow of collected funds goes to the Abandoned Mine Reclamation Fund to finance restoration of abandoned sites. The act established the Office of Surface Mining Reclamation and Enforcement; it controls surface mining operations, reviews and approves state programs, and conducts enforcement when necessary. SMCRA Title IV funds can be used to reclaim abandoned, non-coal hard rock mines such as legacy uranium mines.

Table 2 continued. ***Summary of key federal environmental laws and regulatory requirements for federal lands with respect to uranium mining and milling.***

1978	Uranium Mill Tailings Radiation Control Act (UMTRCA) (codified under 42 U.S.C. 2022 and 92 Stat. 3021)	UMTRCA provides a program of: assessment and remedial action at inactive uranium mill sites in order to stabilize and control radioactive mill tailings in a safe and environmentally sound manner to minimize radiation hazards to the public; and regulation of mill tailings or thorium ore processing at active mill operations after termination of such operations in order to stabilize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public. Title I covers inactive mill sites that were licensed by the AEC and stopped operating after 1978. Title II covers mill sites that were licensed by the NRC. Generally, EPA is responsible for environmental health standards and compliance; NRC is responsible for regulating site cleanup and transfer of the license to DOE or state for perpetual care; and DOE is responsible for long-term perpetual care.
1980, 1986	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (codified generally at 42 U.S.C. 9601-9675) (codified at 42 U.S.C. 9601-9675; 26 U.S.C. 4611,4661, 4671, 59A, 9507; 10 U.S.C. 2700-2710)	CERCLA (aka Superfund) focuses on the cleanup of contamination resulting from the past release of hazardous substances, but excludes petroleum which primarily is covered under the Oil Pollution Act. It provides broad federal authority to respond directly to releases or threatened releases of hazardous substances, pollutants, and contaminants including radionuclides that may endanger public health or the environment. It authorizes short-term, prompt responses/removals and long-term remedial actions like those found at National Priority List (NPL) sites. 1986 Superfund Amendments & Reauthorization Act provided important additions and changes in the program.
1974	U.S. Forest Service, Mining Regulations, Mineral Management, 36 CFR 228	Sets forth rules & procedures on how US Forest Service lands are to be used by authorized mining in such a manner so as to minimize adverse effects on surface resources.
1981	U.S. Bureau of Land Management, Mineral Land Management, 43 CFR 3809	The purposes of this subpart are to: (a) Prevent unnecessary or undue degradation of public lands by operations authorized by the mining laws. Anyone intending to develop mineral resources on the public lands must prevent unnecessary or undue degradation of the land and reclaim disturbed areas. This subpart establishes procedures and standards to ensure that operators and mining claimants meet this responsibility; and (b) Provide for maximum possible coordination with appropriate State agencies to avoid duplication and to ensure that operators prevent unnecessary or undue degradation of public lands.

Table 3. ***Summary of New Mexico environmental statutes, regulations, guidance, and information pertaining to uranium mining and milling operations and cleanup.***

Year	Environmental Law	Summary
1931	NM Statute Annotated, §72-1-1.	NM Constitution declared ground water to be public property where the State is not the owner, but the trustee. Ground water subject to appropriation-beneficial use through state water master (Office of the State Engineer-OSE) and permits.
1963	Public Nuisance Statute §30-8-1	Not designed to provide environmental protection and mine cleanup.
1974	NM Environmental Improvement Act (NMEIA) (NMSA74-1-1, Revised 2000)	NMEIA created Environmental Improvement Board (EIB) to perform environmental management, consumer protection of day-to-day activities: 1) food protection and 2) water supply protection.
1967, 1974	NM Water Quality Act NMWQA) (NM Statute Annotated, NMSA 74-6-1, Revised 2000)	NMWQA created the NM Water Quality Control Commission to adopt standards for surface water and ground water, and prevent or abate water pollution through the discharge permit (DP) program.
1974	NM Water Quality Control Commission (NMWQCC) Regulations (NMAC §§20.6.2. 3101 *et Seq.* and 20.6.2.4101 *et Seq.*)	NMWQCC Regulations were created to protect ground water with a total dissolved solids (TDS) content less than 10,000 mg/L by discharge permit (DP) program. DPs allow discharge of contaminants of concern (COCs) and degradation of water quality up to state standards. If state ground water protection standards are exceeded then Sec. 4103 applies & pollution in excess of standard must be abated according to an abatement plan
1978	NM Statutes 1978: Hazardous Waste Act, Chapter 74, Environmental Improvement, Ar. 1, 2, 3, 4, 6 & 9; Surface Mining Act, Sec. 69-25A-1 et Seq.; Mining Act Sec. 69-39-1 et Seq.; Mine abandonment, fencing, warning notices Sec.69-12-4; Mine abandonment, precautions, Sec. 69-27-3.	1978 Hazardous Waste Act and Mining Act statutes pertain to or provide guidance and requirements for permitting, operating, and reclaiming-remediating hazardous waste and mine sites that have the potential to pollute surface and ground waters in excess of state water quality standards.
1993	NM Mining Act (NMMA) NMSA 1978, Section 69-36-1 *et Seq.*; NMAC 19.10.5.	NMMA requires new, non-coal hard rock mines to be designed & operated in a manner consistent with a State-approved reclamation plan that is then implemented by the mine operator. New and existing mining operations (i.e. legacy uranium mines) are required to have an updated mine permit, and Close Out Plan by end of 1997. After the Close Out Plan is approved, financial assurance is required to cover the estimated cost for mine closure. Where a Stage 1 Abatement Plan may be required, it includes the vadose zone potential sources of contaminants to surface and ground water (e.g. heavy metals from mine waste rock & mine discharge water solid residues in historical drainages?).

Table 3 continued. ***Summary of New Mexico environmental statutes, regulations, guidance, and information pertaining to uranium mining and milling operations and cleanup.***

Year	Environmental Law	Summary
March 2014	Draft Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico	The NM Mining and Minerals Division (MMD) & the NM Environment Department (NMED) have developed draft general guidance to assist existing uranium mine site responsible parties in addressing soil radiation reclamation. Section 2.0, p. 8, proposes that existing uranium mine soil reclamation levels be compliant with 40 CFR192 & 10 CFR 40 which is the EPA UMTRCA 5/15 standard: 1) background + 5 pCi/g Ra-226 in the 0-15 cm of soil; and 2) background + 15 pCi/g Ra-226 in the 15 cm and greater depth of soil. On site disposal cell evapotranspiration cover recommended with erosion & stability design and engineering. Possible to place surface mine soil back underground/into dry mine on a case-by-case basis. Self-sustaining ecosystem requirement must be factored into disposal design
April 2014	Draft Guidance for Meeting Radiation Criteria Levels and Reclamation at New Uranium Mining Operations	MMD provides this draft guidance to assist operators and regulators in addressing radiation at new uranium mine sites as part of reclamation activities. Emphasizes the return of the mining area to pre-mining conditions & reclamation to re-establish a self-sustaining ecosystem. Section 3.4 describes the new uranium mine radiation cleanup level to be the EPA UMTRCA 5/15 standard: 1) background + 5 pCi/g Ra-226 in the first 0-15 cm of soil; and 2) background + 15 pCi/g Ra-226 in the 15 cm and greater depth of soil.

Table 4. ***Summary of abandoned uranium mine cost estimates for reclamation and remediation based on production-size category (after DOE, 2014b).***

Tons	Mine production size	Reclamation	Remediation
0-100	Small	$11,00-$51,00	$13,000-$55,000
100-1,000	Small/medium	$11,000-$80,000	$16,000-$72,000
1,000-10,000	Medium	$46,000-$200,000	$110,000-$800,000
10,000-100,000	Medium/large	$270,000-$680,000	$2,600,000-$6,600,000
100,000-500,000	Large	$560,000-$1,400,000	$5,000,000-$15,800,000
>500,000	Very large	Not estimated	Not estimated*

*Note: DOE review of historical costs for the remediation of three Very Large mines indicated a range of $6,298,000-$204,666,000 in January 2014 dollars.

Table 5. ***Status and comments on EPA Five-Year Plan, Grants Mining District six major objectives and action plan tasks during 2010-2014.***

EPA FYP GMD Major Objective	Responsible agencies	Federal &/or state program to administrate	Action Plan Task evaluation for progress &/or completion	Comments about major objective & Action Plan Tasks
1. Study & monitor ground water supply for contamination	EPA, NMED, NRC, DOE	EPA Region 6 Superfund; UMTRCA; NMED Superfund, MECs-DP	Tasks 1, 3, & 4 completed & ongoing. Task 2 some progress-not completed. Task 5 Public updates not completed twice per year.	Task 2: regional hydro-geochemical study to evaluate nature & extent of anthropogenic & natural COC sources & pathways to ensure safe drinking water supply. NEED IMPLEMENTATION PLAN.
2. Assess & remediate legacy U mine impacted areas	NMED, EMNRD-MMD, BLM, USFS, EPA	NMWQA, NMMA, 36 CFR 228, 43 CFR 3809, CERCLA	Tasks 1, 3, 4 & 5: some progress but not completed. Tasks 2 & 6 mostly completed. Task 7 Public updates not completed twice per year.	Task 1: Prioritize sites for assessment & remediation. Task 2: Conducted screening assessments on approximately 73% of all mine sites. Task 3: Plan investigations at priority sites. Task 4: regional hydro-geochemical study to evaluate nature & extent of anthropogenic & natural COC sources & pathways to ensure safe drinking water supply. Task 5: Assess & mitigate impacted areas based on priorities using NMMA & MARP requirements for permitted mine closure & abatement plan for DP closure. NEED IMPLEMENTATION PLANS FOR TASKS 1, 3, 4, & 5.
3. Remediate, close & monitor mill sites	NRC, DOE, EPA, NMED	UMTRCA; CERCLA; NMWQA-DP Program	Tasks 1-4 show progress, completion, & ongoing activities.	Ambrosia Lake UNC Phillips; Bluewater; & L-Bar Disposal Sites under DOE Legacy Management for long-term care & monitoring. Ambrosia Lake Rio Algom & Homestake-Barrick mill sites under NRC license closure requirements. Also EPA CERCLA Superfund requirements apply at Homestake, and NMWQA DP Program apply at Rio Algom & Homestake.
4. Assess & remediate residential structures	EPA, NMED	EPA Region 6 Prevention & Response Branch	Tasks 1-3 completed & still ongoing.	ASPECT aerial radiological surveys & hazardous release documentation assessment performed. 891 structures assessed by March 2014. 128 residential sites remediated. 19 properties in Morman Farms area to be remediated. Acoma Pueblo assessment ongoing.

Table 5 continued. ***Status and comments on EPA Five-Year Plan, Grants Mining District six major objectives and action plan tasks during 2010-2014.***

EPA FYP GMD Major Objective	Responsible agencies	Federal &/or state program to administrate	Action Plan Task evaluation for progress &/or completion	Comments about major objective & Action Plan Tasks
5. Evaluate & propose Jackpile Mine to place on NPL & remediate under CERCLA	Laguna Pueblo, EPA, BIA, IHS, ATSDR, BLM	CERCLA RI/FS Process leading to ROD & implementation of remedy	Tasks 1-4 completed.	Jackpile placed on NPL December 2013. HRS evaluation indicates 1996 mine surface reclamation unsuccessful at preventing U & Mn in pit waters from migrating into surface & ground water. Approximately 5.4 miles of surface water reach down stream of pits contaminated w/ U & Mn.
6. Conduct voluntary biomonitoring of uranium in Grants area	NM Dept. of Health, IHS, ATSDR, NMED	Check resident urine U level in Grants region & compare to state & national average levels	Tasks 1-3 completed.	In 2011 a state biomonitoring program tested 99 voluntary samples of urine for U levels from residents in Grants/Milan & Laguna Pueblo. Results indicate that residents of NM have 6 to 9 times higher urine U levels (0.030-0.045 ug/L) than the national average (0.005 ug/L).