HOMESTAKE
Grants Project

Homestake Mining Company of California

David W. Pierce
Closure Manager

28 February 2020

Document Control Desk
U.S. Nuclear Regulatory Commission,
Washington, DC 20555–0001

Mr. Ron Linton, Project Manager
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Decommissioning, Uranium Recovery & Waste Programs
Office of Nuclear Materials Safety and Safeguards
MS T-5A10, 11545 Rockville Pike
Rockville, MD 20852

RE: Homestake Mining Company of California – Grants Reclamation Project – Environmental Report in Support of Request for Amendment to License No. SUA-1471

Dear Mr. Linton:

Please find attached the Homestake Mining Company of California (HMC) Environmental Report (ER) for the previously submitted License Amendment Request including the Groundwater Corrective Action Program Report (ML19354B965). This ER is submitted to satisfy Criterion 9 of 10 CFR 40 Appendix A and NRC's obligations under 10 CFR 51.

Thank you for your time and attention on this matter. If you have any questions, please contact me via e-mail at dpierce@barrick.com or via phone at 505.238.9701.

Respectfully,

David W. Pierce

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Enclosures:

Attachment 1 – HMC Environmental Report for the Groundwater Corrective Action Program

ATTACHMENT 1

HMC Environmental Report for the Groundwater Corrective Action Program

HOMESTAKE MINING COMPANY OF CALIFORNIA

Grants Reclamation Project

ENVIRONMENTAL REPORT
For the Groundwater Corrective Action Program (December 2019)

Radioactive Materials License #SUA-1471

Submitted:
February 2020

Submitted To:
United States Nuclear Regulatory Commission

Submitted By:
Homestake Mining Company of California

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1.0 INTRODUCTION

1.1 Introduction

Homestake Mining Company, Grants Reclamation Project (GRP) is submitting this environmental report (ER) to the United States Nuclear Regulatory Commission (NRC) to support the amendment of the present license SUA-1471 to modify the Groundwater Corrective Action Plan, as requested in December 2019.

The GRP is owned and operated by Homestake Mining Company of California (HMC). The GRP occupies approximately 1,085 acres and is located 5.5 miles north of Milan, New Mexico, in Cibola County (Figure 1-1). The GRP is located at longitude -107.865 and latitude 35.241 degrees. The GRP is a former uranium mill that processed ore from local mines in the Ambrosia Lake and Mount Taylor districts between 1958 and 1990. Groundwater contamination from HMC's milling operations was first discovered in 1961 (Chavez, 1961) and further investigated by the U.S. Environmental Protection Agency in 1974 (EPA, 1975). Groundwater restoration began in 1977.

The GRP was initially regulated by the U.S. Nuclear Regulatory Commission (NRC) and the New Mexico Environmental Improvement Division (NMEID). The GRP is a designated Uranium Mill Tailings Reclamation and Control Act (UMTRCA) Title II site. Portions of the GRP were added to the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at the request of the State of New Mexico in 1983 as a result of groundwater contamination. The GRP is currently regulated by the NRC, the U.S. Environmental Protection Agency (EPA), and the New Mexico Environment Department (NMED).

Milling activities have resulted in impacts to the alluvial groundwater beneath the GRP. A groundwater corrective action program has been operating at the GRP since 1977 (Kleinfelder, 2007). The GRP groundwater corrective action program is designed to remediate hazardous and non-hazardous constituents of 11e.(2) Byproduct Material to levels that meet the groundwater protection standards within each aquifer affected by activities at the GRP (Table 1-1). This program began in 1977 and is projected to continue through 2030 with final site closure and transfer estimated in 2035. The program is implemented using an adaptive, ongoing strategy that includes source control, plume control, evaporation, and water treatment. The groundwater restoration program is currently authorized and regulated under the NRC License SUA-1471 and NMED Discharge Permit DP-200 (NMED, 2014).

The groundwater restoration program is managed under a 1989 Groundwater Corrective Action Program (GCAP) that was approved by the NRC. Two subsequent CAPs have been submitted to the NRC in 2006 and 2012, and have been reviewed and commented on, but have not been approved. The GRP submitted an updated GCAP in December 2019 as a response to the Confirmatory Order issued by NRC on March 28, 2017 (Radioactive Materials License SUA-1471, Condition 44).

1.2 Facility Description

The GRP is a former uranium mill in Cibola County, New Mexico that processed ore between 1958 and 1990. Figure 1-1 presents the location of the GRP within the State of New Mexico in relation to Milan and Albuquerque. The GRP is located 5.5 miles north of the City of Grants and Milan, New Mexico. The site occupies approximately 1,085 acres primarily in Section 26, Township 12 North, Range 10 West.

Milling using alkaline leach circuits occurred at the site between 1958 and February 1990 (Kleinfelder, 2007). Most of the mill structures were decommissioned between 1993 and 1995 (ARCADIS, 2013) Features (Figure 1-2) currently existing at the site are the Large Tailings Pile, the Small Tailings Pile, groundwater restoration and monitoring wells, a reverse osmosis (RO) water treatment system, tailings flush and dewatering system, three lined evaporation ponds, two collection ponds, an office building and other support structures. The existing structures are related to the operation and maintenance of the groundwater restoration program.

1.2.1 Facility History

Milling using alkaline leach circuits occurred at the site between 1958 and February 1990 (Kleinfelder, 2007). Tailings generated during milling were slurried and disposed in the Small Tailings Pile and the Large Tailings Pile. The Small Tailings Pile is in the southwest quarter of Section 26, Township 12 North, Range l0 West. It was used for disposal of tailings generated for uranium ore processed under U.S. Atomic Energy Commission contract and contains about 1.2 million tons of tailings and covers about 40 acres (Kuhn and Jenkins, 1986). The unlined Small Tailings Pile was constructed with a perimeter embankment, and tailings disposal occurred within the embankment (Kuhn and Jenkins, 1986). The Large Tailings Pile was also an unlined impoundment, located in the north quarter of Section 26, Township 12 North, Range l0 West that was operated from 1958 through 1990, covers approximately 234 acres, and rises to between 70 and 90 feet above the toe of the impoundment. The Large Tailings Pile contains about 21 million tons of tailings.

In 1990, a lined evaporation pond (Evaporation Pond No. 1 or EP-1) was constructed within the Small Tailings Pile and occupies most of the interior surface area of the original Small Tailings Pile. EP-1 was used to hold water discharged from the groundwater restoration collection wells (AK Geoconsult, 1991), and continues to be used for storage and disposal by evaporation of RO treatment system brine and other poor-quality water. Prior to the construction of EP-1, two small lined collection ponds constructed west of the Small Tailings Pile in 1986 were used to store and evaporate collected groundwater. Prior to the end of milling and the construction of evaporation or holding ponds, collected groundwater was introduced to the mill process water with some recovery of uranium in the mill. A second evaporation pond, EP-2, located on the western side and directly adjacent to the Small Tailings Pile and extending to the small collection ponds was put into service in 1996. A third evaporation pond, EP-3, was constructed north of the Large Tailings Pile in 2010. All ponds are expected to remain in service until groundwater restoration is complete.

The mill and associated structures were subsequently decommissioned and demolished between 1993 and 1995. Debris were buried on-site in eight pits. Pits were typically twenty feet deep and debris was placed into the pits in 5-foot lifts. After each lift was placed, a slurry grout was pumped into the pit to fill voids around the debris and to solidify the debris to prevent contact with the environment. Once filled, a soil cover was placed over the pits and surrounding areas and graded for positive drainage. The soil cover was approximately two feet thick over the mill area but ranged up to 4 to 5 feet thick over some of the pits. A levee north of the mill area was also constructed to divert runoff around the former reclaimed mill area.

After EPA's investigation of groundwater contamination from HMC's operations (EPA, 1975), additional well installation, groundwater sampling and further studies were undertaken to identify and delineate seepage impacts from HMC's uranium milling operations. The result of the studies was the identification of seepage impacts in areas of the alluvial aquifer and the development of a Ground Water Protection Plan Agreement in 1976 between HMC and the State of New Mexico Environmental Improvement Division, which regulated groundwater restoration (Hydro-Engineering, 1983). For the initial corrective action activities, HMC installed a series of collection wells that began operating in 1978, and a line of injection wells that started operating in 1977. Since the Ground Water Protection Plan was established in 1976, numerous wells have been installed and groundwater restoration activities have been expanded to include the Upper, Middle and Lower Chinle aquifers as well as the alluvial aquifer.

The first significant water treatment effort for collected groundwater occurred with the operation of the RO treatment plant in 1999. The RO treatment plant was significantly modified and expanded in 2014 and 2015 to improve treatment and increase capacity. In 2010, a zeolite water treatment system pilot test with a capacity of 50 gallons per minute (gpm) was constructed on top of the Large Tailings Pile near the center. The zeolite water treatment system consisted of two small synthetically lined cells containing zeolite within a constructed berm. In 2012 and 2013, an expanded 300 gpm capacity zeolite water treatment system with three synthetically lined cells was installed adjacent to the 50 gpm system. In 2015, a larger 1200 gpm capacity zeolite system with twelve synthetically lined cells was installed on top of the Large Tailings Pile in the southeast corner. The operating zeolite systems are used to treat collected groundwater from the North and South Off-Site areas.

A groundwater land treatment program was first undertaken in 1999 with the installation of one center pivot sprinkler irrigation system in Section 33 and one flood irrigation system in Section 34 (Figure 1-1). Land application began in 2000 and ended in 2012. The purpose of the land treatment program included collection and capture of mildly impacted groundwater for irrigation to reduce impacts of past seepage from the tailings, promote vegetative growth in irrigated areas to reduce wind erosion and windblown dust, and to produce a crop. The initial land treatment was expanded to include an additional center pivot sprinkler in the North Off-Site area and 24 additional acres of flood irrigation areas in the South Off-Site area. After land application ceased in 2012, groundwater from the Off-Site areas was treated with the zeolite treatment systems.

Groundwater subjected to land treatment was an integral part of the groundwater restoration program. Prior to 2002, HMC had 270 acres of land under treatment consisting of center pivot spray irrigation on 150 acres (Section 33, Township 12 North, Range 10 West) and flood irrigation over 120 acres (Section 34, Township 12 North, Range 10 West). During 2002, an additional center pivot irrigation system was commissioned in Section 28, Township 12 North, Range 10 West for an additional 60 acres. In 2003, 24 acres of land was added to the flood irrigation system in Section 33, Township 12 North, Range 10 West. In 2005, the 60-acre center pivot irrigation system was expanded by 40 acres to encompass 100 acres in Section 28 Township 12 North, Range 10 West.

1.3 Operations

The operations currently conducted at the GRP are associated with groundwater corrective action and environmental monitoring activities.

1.3.1 Monitoring Stations

Monitoring of groundwater, total suspended particulates, radionuclides, radon and gamma exposure occurs as outlined in the RML SUA-1471, the radiation protection program (ERG, 2019) and the Compliance Monitoring Plan (HMC and Hydro-Engineering, 2017).

The GRP continuously samples total suspended particulates at seven locations (Table 1-2 and Figure 1-3). Radon-222 gas concentration in ambient outdoor air are monitored on a continuous basis at the nine locations identified in Figure 1-3. Annual radon flux measurements occur in the fall as two separate deployments, consisting of 100 canisters per deployment on the Large Tailings Pile and Small Tailings Pile respectively.

Gamma dose rates are continuously monitored using optically stimulated luminescence (OSL) dosimeter badges placed at eight locations identified in Figure 1-3. Occupational and public doses are monitored, and results presented semi-annually as required by RML SUA-1471. Tables 1-3 and 1-4 outline the water quality sampling frequency and parameters monitored. The locations of the groundwater monitoring wells are provided in Figures 1-4 through 1-8.

1.3.2 Corporate Organization and Administrative Procedures

The Closure Manager has overall policy and management responsibilities for the GRP. The Closure Manager is responsible for enforcing the policies and procedures and has the ultimate on-site authority. Written operating procedures have been established for routine production activities involving the handling and processing of radioactive materials and routine radiation safety practices. The GRP organizational chart is provided as Figure 1-9.

The Safety, Health and Environmental Compliance (SHEC) Manager reports to the Closure Manager and has the authority and responsibility to ensure that GRP monitoring activities are compliant with the technical and quality assurance requirements in the Quality Assurance Plan. The SHEC Manager maintains familiarity with the environmental and operational monitoring, remediation, and quality programs, and related documents and requirements.

The Radiation Safety Officer (RSO) reports directly to the Closure Manager and is responsible for compliance with all environmental health and safety regulations, implementing all radiological and environmental monitoring procedures, and for compliance with the regulations and requirements administered by the NRC.

The Site Shift Supervisor reports to the Closure Manager. The Site Shift Supervisor has the authority and responsibility to ensure sampling programs are conducted in accordance with the quality assurance documents and standard operating procedures identified in the Quality Assurance Plan.

The Environmental Technicians report to the Site Shift Supervisor and have the responsibility to conduct field sampling programs in accordance with the quality assurance documents and standard operating procedures identified in the Quality Assurance Plan.

The Radiation Safety Technicians (RSTs) report to the Radiation Safety Officer and have the responsibility to conduct radiological field monitoring and sampling programs in accordance with the quality assurance procedures incorporated into the Quality Assurance Plan. Because some GRP personnel fill dual functions as environmental technicians and Radiation Safety Technicians, when functioning as Radiation Safety Technicians, they report directly to the Radiation Safety Officer.

All activities related to assessing the environmental and health impacts from operations are conducted using Standard Operating Procedures.

1.3.3 Personnel Qualifications and Training

Minimum education and experience qualifications for the Radiation Safety Officer, Environmental Technicians, and Radiation Safety Technicians are identified in Section 2 of the GRP Quality Assurance Plan (HMC, 2018a).

The radiological protection training program for all workers includes providing basic radiation protection training for new employees and contractors, on-the-job training, and annual refresher training. The formal training includes the fundamentals of radiation, regulatory limits, methods for limiting radiation exposure, and personnel monitoring methods.

1.3.4 Security

The boundary limits of the processing facility are posted and enclosed by a fence. The RO plant, the office building, the collection ponds, the evaporation ponds and the entire tailings disposal area are located within the controlled access area boundary of the GRP. The controlled access area is posted with "Caution Radioactive Materials" signs per 10 CFR 20.1902. Access to all areas is controlled by fences and gates. Warning and information signs are posted near the main gate. Perimeter checks of the fence are conducted daily by GRP personnel. The RO plant and the office building have alarms that notify law enforcement.

1.3.5 Radiation Safety

The basis for the radiation safety program is to maintain radiation exposures to levels that are as low as reasonably achievable (ALARA) for all employees, contractors, visitors, and members of the general public per 10 CFR 20. The implementation of a successful ALARA program is the responsibility of management and all workers. Workers and management have the responsibility for developing work practices that minimize radiation exposure. ALARA is a primary consideration in worker training and developing work plans.

The Radiation Safety Program is implemented by the Radiation Safety Officer and a staff of technicians. The program consists of employee training, work-place monitoring, environmental and effluent monitoring, personnel monitoring and dose assessment, records management, and regulatory compliance. Supporting activities include job planning assistance, preparing radiation work permits, preparing and maintaining standard operating procedures, monitoring equipment calibration and maintenance, and conducting audits.

1.4 The Proposed Action

The proposed action, presented in detail in the proposed Groundwater Corrective Action Program (HMC, 2019) and summarized in Section 2.1.2 of this Environmental Report, will consist of continued groundwater collection, treatment, and injection of fresh water within the Alluvial and Chinle aquifers for approximately ten years, followed by monitored natural attenuation. Monitored natural attenuation may be supplemented with passive treatment using permeable reactive barrier technologies pending laboratory and field testing to determine its applicability to the GRP. Groundwater and operational monitoring will be conducted to document remediation progress and to evaluate the performance and effectiveness of groundwater collection, injection, and treatment, monitored natural attenuation, and permeable reactive barriers, if installed.

Once active groundwater remediation ceases and the zeolite treatment systems are decommissioned, the Large Tailings Pile will be capped with a final cover designed to limit precipitation infiltration through the tailings and seepage to the underlying aquifers. The Small Tailings Pile will be capped with a final cover after groundwater restoration is deemed complete and all materials that do not meet free release criteria have been disposed in the Small Tailings Pile. The GRP will implement administrative controls (e.g., deed and groundwater use restrictions), which will be durable, enforceable and transferred to the long-term custodian.

1.5 Purpose and Need for the Proposed Action

The purpose of the proposed action is to restore groundwater conditions to meet the groundwater protection standards in RML SUA-1471 Condition 35B. HMC is authorized by RML SUA-1471 to possess, incidental to decommissioning, residual uranium and 11e.(2) Byproduct Material in the form of uranium tailings and other byproduct waste generated by the GRP past milling operations in accordance with the license. Legacy operations have resulted in release of 11e.(2) byproduct material to the groundwater system and, as required by RML SUA-1471 Condition 35, the GRP is in the process of corrective action for groundwater restoration. The groundwater corrective action program is designed and operated to remove targeted mill-derived constituents from the groundwater using injection of freshwater from deep wells or from the GRP reverse osmosis plant in order to achieve the groundwater protection standards identified in License Condition 35B. The requested amendment to RML SUA-1471 Condition 35 is needed to license expanded corrective action infrastructure and operations. The expanded groundwater corrective action program will aid in the attainment of the groundwater restoration goal of restoration of the groundwater quality of the aquifers, impacted by mill-derived constituents, to as close as practicable to upgradient groundwater quality.

1.6 Applicable Regulatory Requirements, Permit and Required Consultations

1.6.1 NRC Source Materials License SUA-1471

The GRP operates under NRC Source Materials License SUA-1471 issued on November 10, 1986 and subsequent amendments. The license authorizes HMC to possess, incidental to decommissioning, residual uranium and 11e.(2) Byproduct Material in the form of uranium waste tailings and other byproduct waste generated by the GRP past milling operations in accordance with their license.

Groundwater restoration is regulated under License Condition (LC) No. 35. This program is separate from the requirements in LC 15. Requirements specified in LC 35 include the following:

A. Per License Amendment No. 55, HMC shall implement the groundwater monitoring shown in Tables 2-1 and 2-2 of the Groundwater Monitoring Plan submitted by the licensee dated November 20, 2017 (ML18018A102), as updated by the licensee in correspondence dated October 8, 2019 (ML19281C055; HMC, 2019).

B. The groundwater protection standards (Table 1-1) for the GRP are established for each designated aquifer/zone as described in Ground-Water Hydrology for Support of Background Concentration at the Grants Reclamation Site (Hydro-Engineering, 2001) and Background Water Quality Evaluation of the Chinle aquifers (HMC and Hydro-Engineering, 2003). The constituents listed in Table 1-1 for the alluvial aquifer must not exceed the specified concentration limit in any of the monitoring wells, except for the background alluvial and San Andres monitoring wells as described in the Groundwater Monitoring Plan (ML19217A355).

C. Implement the corrective action program described in the September 15, 1989 submittal, as modified by the reverse osmosis system described in the January 15, 1998 submittal, excluding all sampling and reporting requirements for Sample Point 1, with the objective of achieving the concentrations of all constituents listed in License Condition 35B. Composite samples from Sample Point 2 (SP2) will be taken monthly and analyzed for the constituents listed in License Condition 358; the results of these analyses will be reported in the semi-annual and annual reports required by License Conditions 15 and 42.

D. Operate Evaporation Ponds Numbers 1, 2, and 3 (EP-1, EP-2 and EP-3), and enhanced evaporation systems located in each pond as described in the June 8 and 28, 1990; July 26, August 16, August 19, September 2 and 15, 1994; October 25, 2006, February 7, 2007, July 18, 2007, and March 17, 2008, submittals. Monitoring and mitigation measures for EP-3 contained in the HMC Environmental Report dated January 30, 2007, are incorporated into this License Condition by reference.

E. Operate the zeolite water treatment systems located on the Large Tailings Pile as described in the December 11, 2017 (ML17361A006), February 22, 2018 (ML18066A583), and May 17, 2019 (ML19149A366), submittals, including all monitoring and mitigation requirements specified therein.

F. Submit by March 31 of each year, a performance review of the corrective action program that details the progress towards attaining groundwater protection standards.

License Conditions 15, 16, and 43 also apply to the GCAP. License Condition 15 indicates that the results of all effluent and environmental monitoring required by this license and regulation shall be reported semi-annually, by March 31 and September 30. All groundwater monitoring data shall be reported per the requirements in License Condition 35.

License Condition 16 specifies that before engaging in any activity not previously assessed by the NRC, the licensee shall prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity may result in a significant adverse environmental impact that was not previously assessed, or that is greater than that previously assessed, the licensee shall provide a written evaluation of such activities and obtain prior approval of the NRC in the form of a license amendment.

License Condition 43 indicates that before engaging in any developmental activity not previously assessed by the NRC, the licensee shall administer a cultural resource inventory. All disturbances associated with the proposed development will be completed in compliance with the National Historic Preservation Act (as amended) and its implementing regulations (36 CFR 800), and the Archaeological Resources Protection Act (as amended) and its implementing regulations (43 CFR 7). In order to ensure that no unapproved disturbance of cultural resources occurs, any work resulting in the discovery of previously unknown cultural artifacts shall cease. The artifacts shall be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance of the area shall occur until the licensee has received authorization from the NRC to proceed.

The proposed action updates the licensed infrastructure and operations in License Condition 35C.

1.6.2 NRC Confirmatory Order

The NRC issued a Confirmatory Order on March 28, 2017 in response to a records review that identified five apparent violations of the source materials license conditions. The order modified the radioactive materials license, in part to address the GCAP, including:

- As required by Confirmatory Order Item 6, submit a revised GCAP to the NRC on which NRC and the GRP will work, aggressively and in good faith, toward a goal of final approval of the GCAP within a year from the date of submittal;
- As required by Confirmatory Order Item 8, use the mass balance methodology described in its updated 2012 GCAP submittal (HMC, 2012), incorporating the issues raised in the Requests for Additional Information provided by NRC (ADAMS Package No. ML13360A224), and adapting

the methodology for the purpose of completing an analysis of the re-injection system's impact to the time estimate for completion of the GCAP;

- As required by Confirmatory Order Item 11, modify License Condition 35C;
- As required by Confirmatory Order Item 12, Sample all required composite samples from Sample Point 2 (SP2) monthly and will report the results of those sample results in the semi-annual and annual reports required by License Conditions 15 and 42; and
- As required by Confirmatory Order Item 13, modify License Condition 15, to read as follows: "The results of all effluent and environmental monitoring required by this license and regulation shall be reported semi-annually, by March 31 and September 30. All groundwater monitoring data shall be reported per the requirements in License Condition 35."

On October 11, 2018, the GRP requested an extension of the GCAP deadline from the end of calendar year 2018 to December 18, 2019. On December 5, 2018, the GRP provided additional justification for an extension in response to an NRC request for information dated November 28, 2018. NRC approved the GCAP submittal date extension request on December 31, 2018. The GCAP was submitted December 18, 2019.

1.6.3 NMED Discharge Permit DP-200

Groundwater discharge at the GRP is regulated under NMED Discharge Permit DP-200 which was modified and renewed on September 18, 2014. Permit DP-200 authorizes specific discharges associated with ongoing closure and groundwater clean-up activities to protect public health, safety and the environment, including for present and future groundwater and surface water uses. Permitted discharges include the ongoing seepage from the Large Tailings Pile and Small Tailings Pile and discharges from the groundwater treatment facilities.

DP-200 (NMED, 2014) increased the maximum treatment capacity and discharge to 5,500 gpm over the previous discharge permits (DP-200 and DP-725). It also allows pilot testing of alternate groundwater treatment technologies and an increase in evaporative capacity. DP-200 requires quarterly, semi-annual, and annual reporting of various groundwater restoration operational activities. The modification of DP-200 subsumed the conditions and requirements of previously issued Discharge Permit DP-725. NMED terminated Discharge Permit DP-725 by letter dated October 27, 2014.

1.6.4 Other Environmental Requirements

Final reclamation activities will require the NRC to perform an evaluation of the environmental impacts associated reclamation activities to comply with the National Environmental Policy Act and NRC's regulations, found at 10 CFR Part 51. The evaluation will describe the affected environment, evaluate the potential environmental impacts of the proposed reclamation actions, and provide monitoring and mitigation measures. Groundwater corrective actions must also be protective of threatened and endangered species and prehistoric and historic sites that may be present at the GRP.

1.6.5 Decommission and Reclamation

Upon completion of groundwater restoration, portions of the GRP previously not reclaimed will be decommissioned and reclaimed in accordance with the Decommissioning and Reclamation Plan (AK Geoconsult and Jenkins, 1993), or the most recent approved version of this Plan. Decommissioning and reclamation will involve final closure of the Large and Small Tailings Piles, closure and demolition of the groundwater treatment systems, closure of the East and West Collection Ponds and EP-1, EP-2, and EP-3, demolition of the remaining site structures, reclamation of the remaining contaminated soil including completion of a final radiological verification survey to demonstrate that the site meets final NRC cleanup criteria, completion of final surface contouring and installation of erosion control structures, application of topsoil and seed to reclaimed areas, and installation of final security features (e.g., fencing, gates, signage).

1.6.6 License Termination and Transition

After groundwater restoration, decommissioning, and reclamation are deemed complete by the NRC, with concurrence from EPA and NMED, the existing GRP radioactive materials license, SUA-1471, will be terminated, and once the NRC approves HMC's funding provision for post-closure long-term monitoring and maintenance, the license and the GRP will be transferred to the Department of Energy, Office of Legacy Management for long-term custody and care under a General License for Custody and Long-Term Care of Uranium or Thorium Byproduct Materials Disposal Sites granted under 10 CFR 40.28. Department of Energy, Office of Legacy Management is then responsible for long-term surveillance and maintenance of the site to ensure protection of human health and the environment. The transition process is detailed in guidance titled "Process for Transition of Uranium Mill Tailings Radiation Control Act Title II Disposal Sites to the U.S. Department of Energy Office of Legacy Management for Long-Term Surveillance and Maintenance" (DOE, 2012).

1.6.7 Consultations

The online United States Fish and Wildlife Service project review process was accessed. The threatened and endangered species that may occur are discussed in Section 3.6. None of the threatened and endangered species were identified as having critical habitat within the boundary identified (Appendix A). No critical habitats under the jurisdiction of the United States Fish and Wildlife Service were identified within the area identified. Several migratory birds were identified as potentially using the area (Appendix A).

Congress enacted the National Historic Preservation Act of 1966, as amended (NHPA) to support and encourage the preservation of prehistoric and historic resources. Section 106 of the NHPA requires federal agencies to take into account the effects of their undertakings on historic properties and allow the Advisory Council on Historic Preservation (ACHP) an opportunity to review and comment on the undertaking. NRC has not yet initiated a Section 106 consultation process related to the reclamation licensing actions for the GRP.

2.0 ALTERNATIVES

This section discusses the alternatives considered for implementation as part of the proposed GCAP. These alternatives were developed by first screening potentially applicable technologies and process options. The treatment technologies and process options were screened against criteria of effectiveness, implement ability, and relative cost with regard to the following general response actions:

- Natural Attenuation
- Institutional Controls
- Removal
- Containment
- Treatment (*in situ and ex situ*)

Based on the treatment technologies and process options screening, retained technologies and process options were assembled into alternatives that were then screened against several criteria. The following alternatives, described below, were developed.

- Alternative 1- Natural Attenuation/No Action
- Alternative 2 - Groundwater Containment and Removal for 24 years
- Alternative 3 - Groundwater Containment and Removal for 10 years and *In Situ* Treatment

Section 6 of the GCAP (HMC, 2019) provides a detailed discussion of corrective measures undertaken to date and operational details for the existing collection, injection, and treatment systems as well as other treatment technologies previously considered for the GRP.

2.1 Detailed Description of Alternatives

2.1.1 No-Action Alternative

The no-action alternative, Alternative 1, is considered in order to provide a baseline to compare the proposed action and reasonable alternatives. The No Action alternative involves cessation of all existing pumping of groundwater, ex-situ treatment of the pumped groundwater, cessation of all associated groundwater monitoring, and completion of decommissioning and surface reclamation of the remaining licensed facilities per the approved Decommissioning and Reclamation Plan (AK Geoconsult and Jenkins, 1993). Under this alternative, there are no related surface impacts other than those already considered with the licensed action of mill decommissioning and surface reclamation. The major impacts of this alternative relate solely to groundwater. Groundwater above the limits established in the radioactive materials license SUA-1471 per 10 CFR 40 Appendix A, Criterion 5B(5), which are:

(a) The Commission approved background concentration of that constituent in the groundwater;
(b) The respective value given in the table in paragraph 5C if the constituent is listed in the table and if the background level of the constituent is below the value listed; or
(c) An alternate concentration limit established by the Commission.

Under the Alternative 1 (Natural Attenuation/No Action), unrestricted access to the hazardous constituents from the licensed 11e.(2) Byproduct Material in groundwater exceeding these limits would occur. This condition would not provide a reasonable assurance of protection of public health, safety and the environment.

2.1.2 Proposed Action

HMC, a wholly owned subsidiary of Barrick Gold Corporation, are names of the organizations sharing ownership of the proposed action. The proposed action, Alternative 3, will consist of continued groundwater collection, treatment, and injection within the alluvial and Chinle aquifers for approximately ten years, followed by monitored natural attenuation (MNA). MNA may be supplemented with passive treatment using permeable reactive barrier (PRB) technologies pending laboratory and field testing to determine its applicability to the GRP. Groundwater and operational monitoring will be conducted to document cleanup progress and to evaluate the performance and effectiveness of groundwater collection, injection, and treatment, MNA, and PRBs.

Institutional controls such as deed restrictions would prevent exposure and use of groundwater until COC concentrations are less than GRP groundwater protection standards (Table 1-1). Deed restrictions would prevent the drilling of groundwater wells to use groundwater for consumption or irrigation.

Once active groundwater remediation ceases and the zeolite treatment systems are decommissioned, the Large Tailings Pile will be capped with a final cover designed to limit precipitation infiltration through the tailings and seepage to the underlying aquifers. The Small Tailings Pile will be capped with a final cover after groundwater restoration is deemed complete and all materials that do not meet free release criteria have been disposed in the Small Tailings Pile. HMC will implement administrative controls (e.g., deed and groundwater use restrictions), which will be durable, enforceable and transferred to the long-term custodian.

2.1.2.1 Groundwater Collection and Injection

Groundwater collection with treatment and injection of treated and fresh waters is the primary GCAP component for the GRP. Groundwater modeling of Alternative 3 predicts that the uranium plume extents and contaminant of concern (COC) concentrations in the alluvial and Chinle aquifers can be retracted from their current extents to within the license boundary and COC concentrations reduced to less than the uranium GRP groundwater protection standards (Table 1-1) within most of the off-site and on-site areas in approximately 10 years at modeled recovery and treatment rates. For the proposed GCAP, HMC estimates that the groundwater collection and injection system under the GCAP will extract between 1,380 and 1,950 gpm of contaminated groundwater for treatment and inject between 1,400 and 1,900 gpm of treated and fresh groundwater for hydraulic plume control. Also in the GCAP, HMC requests approval for bounding collection and injection rates at a total maximum combined discharge rate of 5,500 gpm. The maximum discharge rate shall include total of all discharges to all ponds, and all injection of compliant water.

Under the modeling assumptions, approximately 900 gpm of contaminated groundwater will be collected from the On-Site area, while approximately 1,050 gpm of contaminated groundwater will be collected from the North and South Off-Site areas (Figure 2-1). Approximately 970 gpm of treated water will be injected in the On-Site area, while approximately 900 gpm of treated water will be injected in the North and South Off-Site areas. Approximately 300 gpm of fresh groundwater will be extracted from the San Andres aquifer wells, Deep #1 and Deep #2, and used to mix with treated waters and injection for hydraulic control. The groundwater collection and injection rates simulated in the model are summarized in Table 2-1 and Table 2-2 as originally provided as Appendix E of the GCAP (HMC, 2019). The predicted plume extents and uranium concentrations following ten years of collection, injection and treatment in the alluvial and Upper Chinle aquifers are shown on Figures 2-2 through 2-9 (HMC, 2019). The extent of uranium is discussed when addressing groundwater impacts at GRP because uranium is the COC for which elevated concentrations have historically occurred or extended over the largest area (HMC, 2019).

The actual collection and injection rates used to reduce the plume extents and COC concentrations goal will likely vary from those used in the model and will be modified as needed in response to well performance and groundwater monitoring results. Collection and injection wells used in the model are shown on figures provided in Appendix B (HMC, 2019). The actual wells used to manage the groundwater plumes and COC concentrations will be based on the success and timing of shrinking the constituent plume extents and reducing the COC concentrations to less than the GRP groundwater protection standards (Table 1-1) within the alluvial and Chinle aquifers. Groundwater monitoring results will be used to evaluate the performance and effectiveness of the groundwater collection and injection system. The proposed groundwater collection and injections system will be operated dynamically so that pumping and injection rates may vary as groundwater plume extents and COC concentrations are reduced.

In 2018, groundwater was collected at the GRP at an average rate of approximately 740 gpm and included groundwater from the alluvial (520 gpm) and Upper (130 gpm) and Middle (90 gpm) Chinle aquifers (Figure 2-10). Groundwater was not extracted from the Lower Chinle aquifer in 2018. In 2018, groundwater was injected at an average rate of approximately 745 gpm and included treated and fresh groundwater returned to the alluvial aquifer (678 gpm) and the Upper (21 gpm) and Middle (46 gpm) Chinle aquifers. Fresh water was collected from the San Andres aquifer (128 gpm) and sent to the post-treatment tank to mix with the treated waters before injection. In addition, San Andres groundwater was directly injected at an average rate of approximately 104 gpm into the shallow groundwaters (alluvial aquifer at 82 gpm, the Upper Chinle at 18 gpm and Middle Chinle at 4 gpm). Simulated collection and injection rates are significantly higher in the Alternative 3 model run for Round 1 than actual rates reported in 2018. The re-lining of EP-1 (originally scheduled for 2019, postponed until 2020) is in part the cause of the reduced rates in 2018.

To reduce the volume of water in the evaporation ponds, the treatment rates through the zeolite and reverse osmosis systems were reduced to 300 gpm each toward the end of 2018. The ability to reach the Alternative 3 objectives for the ten years of operation of the system would be dependent on achieving groundwater collection and injection rates similar to those used in the model. As such, the timelines and costs associated with the proposed remedy are optimistic in nature and dependent upon the limitations of the treatment systems and will be further refined in future modeling efforts. The progress made as a function of time can be assumed to be inversely proportional to the treatment rate, thus a reduction of 50 percent in treatment rates would likely lead to a doubling of the time needed to achieve the same progress. The cost associated with variable treatment rates would not follow the same relationship, as there are a number of costs associated that are independent of throughput.

2.1.2.2 Groundwater Treatment Systems

Groundwater treatment of the extracted waters would be accomplished using the reverse osmosis and zeolite treatment systems currently employed at the GRP. These groundwater treatment systems are summarized below and described in detail in Section 6 of the GCAP (HMC, 2019).

2.1.2.2.1 Reverse Osmosis Treatment System

A reverse osmosis treatment system (Figure 2-11) is used to treat groundwater collected from the alluvial aquifer and Upper and Middle Chinle aquifers (about 90 percent) and recycled water from the East and West Collection Ponds (about 10 percent). The RO treatment system is comprised of two equalization basins, two lime/caustic treatment basins, two clarifiers, three low pressure and two high pressure treatment units equipped with microfiltration units, and a post-treatment tank. The RO treatment system is ideally operated at a feed rate of about 900 gpm, so that one of the treatment units can be serviced while groundwater is continuously treated. In 2018, the RO treatment system treated an average of approximately 490 gpm from the alluvial (279 gpm), Upper Chinle (130 gpm), and Middle Chinle (34 gpm) aquifers and Collection Ponds (48 gpm) (Figure 2-10). The RO system is expected to treat up to 900 gpm of contaminated groundwater on an average annual basis under the GCAP. The modeled rates presented are a significant increase from the historic throughput averages and represent maximum rates based upon current and anticipated improvements to the treatment systems. A number of improvements and evaluations have been recently completed to increase throughput but have not been properly tested due to the EP-l re-lining project treatment limitations.

2.1.2.2.2 Post-Treatment Tank

The post-treatment tank receives the RO treatment system produced water, zeolite treated water, and fresh water from the San Andres aquifer for mixing prior to distribution to the injection system. In 2018, the post-treatment tank received approximately 810 gpm of treated and fresh water, which included about 350 gpm from the RO treatment system, 270 gpm from the Zeolite System, and 130 gpm of fresh water from the San Andres aquifer (Figure 2-10). The post-treatment tank is capable of receiving the anticipated volumes of treated and fresh waters under the GCAP.

2.1.2.2.3 Zeolite Treatment System

Zeolite treatment systems constructed on top of the Large Tailings Pile are used to treat off-site groundwaters where uranium is the only constituent that exceeds the GRP groundwater protection standards. Zeolite treatment was first tested at bench scale in 2007 followed by 5 and 50 gpm pilot tests. A full-scale zeolite treatment system with a maximum treatment capacity of 300 gpm was constructed in 2012 followed by a system with a maximum capacity of 1,200 gpm in 2015 (Figure 2-10). To date, the zeolite treatment systems have not been operated at their maximum conceptualized treatment capacities.

The zeolite treatment systems consist of HDPE lined basins equipped with inflow and outflow piping and filled with clinoptilite, a species of zeolite, used to sorb the uranium. Uranium-contaminated groundwaters collected from the off-site areas are pumped to the top of the Large Tailings Pile where they are circulated through the zeolite beds for uranium adsorption and the treated water returned to the post-treatment tank to be combined with other treated and fresh waters for subsequent injection into the alluvial and Chinle aquifers for hydraulic plume control. In 2018, approximately 296 gpm of uranium-contaminated groundwater was treated in the zeolite treatment systems and approximately 267 gpm of treated effluent discharge to the post-treatment tank for subsequent injection for hydraulic control (Figure 2-10) The zeolite treatment systems are expected to treat up to 1,200 gpm of contaminated groundwater on an annual average basis under the GCAP. The modeled rates presented are a significant increase from the historic throughput averages and represent maximum rates based upon current and anticipated improvements to the treatment systems. A number of improvements and evaluations have been recently completed to increase throughput but have not been properly tested due to the EP-1 re-lining project treatment limitations.

2.1.2.2.4 Evaporation Ponds

Evaporation is used to manage and treat effluent waters from the Large Tailings Pile toe drains, reverse osmosis plant process brine, the collection ponds, the zeolite treatment systems, and other excess waters. These waters are sent to evaporation ponds EP-1, EP-2, and EP-3 (Figure 2-11) where the COCs are evapoconcentrated using natural passive evaporation or mechanically enhanced evaporation using spray misters. In 2018, the evaporation ponds received an average of approximately 150 gpm of contaminated water and 28 gpm of precipitation. They are estimated to have evaporated approximately 200 gpm in 2018.

2.1.2.2.6 Permeable Reactive Barriers

After cessation of operation of the groundwater containment and removal system, hydroxyapatite PRBs may be installed (1) within the alluvial aquifer southwest and downgradient of the Large Tailings Pile and (2) within the lower portion of the alluvial aquifer and, to the extent feasible, within the upper portion of the Upper Chinle unit in the area where the Upper Chinle subcrops to the alluvial aquifer, near the southern boundary (toe) of the Large Tailings Pile, The PRBs are designed to treat in-situ impacted groundwater migrating from within the footprint area of the Large Tailings Pile. The PRBs would be installed through injection of sodium phosphate and calcium citrate solutions into the aquifers using existing and new wells to create continuous in situ hydroxyapatite PRBs at the proposed locations and to the proposed depths. The distance between injection wells would be approximately 25 feet and require the installation of a total of approximately 170 new injection wells to complement 25 existing injection wells in these two areas. The conceptual locations and depths of the PRBs are estimated based on the locations where groundwater is anticipated to exceed the GRP groundwater protection standards following completion of active pumping as identified in the model simulation of natural attenuation after ten years of system operation (Appendix E to the GCAP; HMC, 2019).

For the PRB installed in the alluvial aquifer southwest of the Large Tailings Pile, the conceptual PRB design used to evaluate Alternative 3 is approximately 2,400 feet long in an area downgradient of the Large Tailings Pile and oriented perpendicular to groundwater flow (Figure 2-12). The proposed PRB location minimizes the PRB length and uses a natural subcrop in the alluvial aquifer to bound the southern end of the PRB. The total length of the PRB would treat the potential extent of future plume migration in the alluvial aquifer as estimated by the predictive model simulation. For the purpose of this alternative analysis, the PRB would be installed with an average vertical height of 20 feet within the saturated portion of the alluvial aquifer along the proposed length. The depth interval for the 20-feet vertical height PRB is expected to change along the length of the PRB to allow for variability in aquifer conditions (e.g., aquifer dimensions and anticipated contaminant migration pathway characteristics). The width of the PRB along its length is estimated to be at least 25 feet to provide adequate residence time of impacted groundwater within the PRB and sufficient reactive mass to achieve groundwater protection standards for the compliance period.

For the Upper Chinle, the conceptual PRB design assumed for evaluating Alternative 3 is approximately 1,500 feet long in an area along the southern boundary of the Large Tailings Pile (Figure 2-13). The total length of the PRB would treat the potential extent of future plume migration in the lower portion of the alluvial aquifer and, to the extent feasible, the upper portion of the Upper Chinle formation as estimated by the predictive model simulation. For the purpose of this alternative analysis, the PRB would be installed spanning a vertical interval of approximately 30 feet across the bottom portion of the alluvial aquifer and, to the extent proven feasible through additional characterization and testing, the upper portion of the Upper Chinle formation along the proposed length. The width of the PRB along its length is estimated to be at least 25 feet to provide adequate residence time of impacted groundwater within the PRB and sufficient reactive mass to achieve groundwater protection standards for the compliance period.

The conceptual design for the 2,400-ft PRB in the alluvial aquifer assumes 125 wells installed 25 feet apart would be required to inject the hydroxyapatite solutions. The cost estimate assumes 15 of the injection wells currently exist and can be used. The PRB design for the 1,500-ft PRB in the alluvial and Upper Chinle assumes a total of approximately 70 injection wells (including 10 existing) spaced approximately 25 feet apart are required. Although existing monitoring wells would be used to monitor performance (similar to Alternatives 1 and 2), up to 50 new monitoring wells are assumed to monitor PRB installation and evaluate performance.

The feasibility of installing PRBs and the performance of the PRBs at the proposed locations across a vertical interval that includes the lower portion of the alluvial aquifer and the upper portion of the Upper Chinle unit would need to be verified through field and laboratory testing. Although the estimated cost for Alternative 3 does not include bench and field-scale testing, the conceptual design and costs include expansion of the PRBs to add and extend groundwater treatment capacity through the end of the compliance period. Expansion of the PRBs is assumed to occur during Year 25 and would be approximately 75 percent of the scale (breadth) of the previously completed PRB installations. For the Large Tailings Pile, the final cover would be constructed two years after cessation of groundwater containment and recovery operations to manage precipitation and infiltration. The discharge of drainable pore water from the Large Tailings Pile to the toe drains is expected to be minimal and the completion of reclamation will include decommissioning of the toe drain system.

2.1.2.3 Monitoring Systems

2.1.2.3.1 Compliance Monitoring

Groundwater monitoring results would be used to determine COC extents and concentrations over time, to document that natural attenuation is occurring, and to support the design of PRBs (if implemented). Monitoring results would also be used to assess COC concentration trends, reductions in contaminant mass, and/or reductions in plume extent.

Groundwater compliance monitoring per Radioactive Materials License SUA-1471, Condition 35 will continue to be performed to establish impacted and nonimpacted areas and monitor unimpacted areas to demonstrate compliance with the GWPS. It is currently understood that NRC considers all wells in the compliance and corrective action monitoring programs points of compliance for the GWPS. The proposed compliance monitoring program will include sampling and testing of the alluvial and Chinle compliance monitoring wells identified in Table 1-3 (Groundwater Monitoring Plan, Appendix A of the GCAP, HMC 2019). Table 1-3 also specifies the parameter measurements, groundwater analytes and frequency of monitoring. Table 1-4 specifies the analytical suites for testing specified in Table 1-3. Groundwater quality data will be collected in accordance with the approved Quality Assurance Plan (HMC, 2018a).

Based on experience gained from prior and current groundwater collection and injection activities, HMC expects to observe continued decreases in groundwater COC concentrations in the On-site, North Off-Site, and South Off-site Restoration Areas as groundwater collection and treatment continues under the proposed GCAP. Groundwater monitoring data collected under the compliance monitoring program will be primarily used to show where constituent concentrations are below and above the GRP groundwater protection standards, constituent time-series trends, and whether constituent plume extents are being reduced as intended.

Compliance monitoring results would be reported in the Annual Report to demonstrate the effectiveness of the GCAP in limiting contaminant migration into offsite areas and to show where the GWPS are met or exceeded. HMC may also consider assessing plume-scale contaminant concentration changes using rate constants and a mass-based assessment as described in EPA (2002) and contaminant mass flux and discharge calculations (ITRC, 2010). Comparison of changes in constituent concentrations and trends and dissolved constituent mass would help assess the performance and effectiveness of the implemented remedy.

Groundwater compliance monitoring results would be used to demonstrate compliance with License Condition 35B, Criterion 7A, and NUREG-1620 Section 4.4 and to support decisions regarding the effectiveness, including cost, of continuing active groundwater restoration, modifying the existing system, transitioning to other remedial technologies such as MNA or PRBs or developing alternate concentration limits (ACLs) if remediation becomes impracticable.

Groundwater monitoring results would also be used to assess the occurrence and potential impacts of COC concentration rebound as a result of diffusion from low permeability interbeds within the Alluvium and Chinle Formation. Groundwater monitoring would be conducted in accordance with the Groundwater Compliance Monitoring Plan (Appendix A to the GCAP, HMC, 2019) which was recently approved by the NRC on November 12, 2019 as License Amendment 54. Groundwater monitoring results are reported in the Annual Report for the GRP per License Amendment 55, Conditions 15, 35C, 35F, and 42.

2.1.2.3.2 Operational Monitoring

Operational monitoring will be performed to confirm that the collection and injection system wells are maintaining hydraulic control (i.e., gradient reversal) in the area of the Large Tailings Pile. The operational monitoring program will include measurement of collection and injection volumes and rates, groundwater levels, and water quality at SP2. Operational monitoring data will be collected in accordance with the approved Quality Assurance Plan (HMC, 2018a). Operational monitoring results would be used to confirm that the injected waters are being contained, that gradient reversal is maintained, and that the leading edge of the constituent plumes are being retracted and that contaminant migration into offsite areas is limited as intended. The operational monitoring results will also be used to modify collection or injection rates at various well locations to maintain plume hydraulic control, gradient reversal, and optimize system performance. The operational monitoring results will be reported in the Annual Report.

2.1.2.3.3 Treatment System Monitoring

Operational monitoring of the reverse osmosis and zeolite water treatment systems would be used to document that they are performing as intended and within approved bounds/limits, and to identify the timing and need for system repair or upgrade. Operational monitoring would be conducted in accordance with the recently approved Groundwater Compliance Monitoring Plan (Appendix A to the GCAP, HMC, 2019), which includes all influent and effluent locations as well as any other locations that assist in assessing the performance and effectiveness of water treatment. Operational monitoring results are reported in the Annual Report for the GRP per License Conditions 15, 35C, 35F, and 42.

HMC will evaluate the performance of the reverse osmosis and ex-situ zeolite water treatment systems to determine their effectiveness at treating the groundwater constituents extracted from onsite and off-site extraction wells. Influent and effluent from the RO treatment plant and the zeolite treatment systems will be monitored for incoming and outgoing flow volumes and constituent concentrations to evaluate contaminant mass loading to the treatment system, determine treatment efficiency (effluent concentration/influent concentration) and quantify the quantities of groundwater constituents extracted by treatment (influent mass - effluent mass). HMC will also monitor future evaporation rates through time for the existing on-site evaporation ponds (EP-1, EP-2, and EP-3) using pond water levels to calculate weekly water losses.

2.1.2.3 Summary of Major Impacts of the Proposed Action

The major impacts associated with the proposed action are addressed in Section 4 of this ER. In general, the primary impacts relate to irretrievable commitment of groundwater through evaporative loss of between 183,960,000 and 147,168,000 gallons per year for at least ten years.

The proposed action will significantly decrease the volume of groundwater with COC concentrations greater than GRP groundwater protection standards, thus reducing groundwater toxicity. Since additional construction of infrastructure is not needed for the groundwater containment and recovery system, no short-term adverse impacts to the community and the environment are expected.

During operation of the active system for 10 years, potential risks to workers are expected from operating and maintaining the above ground treatment systems that include but are not limited to noise, chemical exposure, and mechanical and electrical energy. Potential risks to workers will be managed through utilizing trained and experienced operators, appropriate personal protective equipment, and standard operating procedures related to health and safety and radiological exposures.

Mitigation measures for the impacts associated with the proposed action are discussed in Section 5 of this ER.

2.1.3 Reasonable Alternatives

An alternative (Alternative 2) to the proposed action and the No Action alternative was screened. Similar to the proposed action (Alternative 3), Alternative 2 includes the use of existing extraction wells, injection wells, and injection trenches to hydraulically contain and remove the dissolved plumes in the alluvial, Upper Chinle, Middle Chinle, and Lower Chinle aquifers. The conceptual design for Alternative 2 includes 24 years of groundwater extraction and injection with the objectives of removing the offsite groundwater plumes and reducing the extent and concentration of COCs impacted groundwater beneath and in the immediate vicinity of the Large Tailings Pile. After the extents of the dissolved plumes in the alluvial aquifer have essentially been reduced to the footprint of the Large Tailings Pile with smaller disconnected plumes above the GRP groundwater protection standard of 0.16 mg/L in the North Off-Site and South Off-Site areas through operation of the groundwater containment and removal system for 24 years, operation would stop and monitored natural attenuation would be utilized to manage and monitor the effect of discharge from the Large Tailings Pile to the groundwater.

As presented in the model predictive simulations (Appendix E to the GCAP; HMC, 2019), the conceptual design for the 24 years of Alternative 2 includes variable extraction and injection locations and flow rates to remove the groundwater plumes. The schedule of extraction and injection locations and flow rates are summarized by areas identified as North Off-Site, South Off-Site, and On-Site in tables and site maps in Appendix E (HMC, 2019). Total extraction rates during the simulated operation period of 24 years range from approximately 850 to 1,950 gallons per minute. Total injection rates range from approximately 905 to 1,900 gpm. In general, total injection and extraction rates are planned to decrease over time as plumes are removed and injection and extraction locations change to further retract and remove the groundwater plumes. The existing reverse osmosis and zeolite treatment systems would be utilized to treat extracted groundwater. Existing evaporation ponds would be used for water storage and disposal.

Institutional controls such as deed restrictions would prevent exposure and use of groundwater until COC concentrations are less than GRP groundwater protection standards (Table 1-1). Deed restrictions would prevent the drilling of groundwater wells to use groundwater for consumption or irrigation.

2.1.4 Alternatives Considered but Eliminated

Three alternatives were developed as part of the selection process for the proposed action. Although some technologies and process options were considered but ultimately not incorporated into the three alternatives, no alternatives were considered but eliminated as discussed in Tables 2-3 and 2-4 (HMC, 2019).

2.2 Cumulative Effects

The primary past, current, and potential future cumulative impact of the groundwater corrective actions and associated alternatives is the irretrievable commitment of groundwater resources through evaporation. To date, millions of gallons of groundwater have been removed from the groundwater system and evaporated as a method treating the brine effluent and regeneration fluids associated with the reverse osmosis and the zeolite treatment systems. Continued pumping, while potentially restoring the area over which groundwater may be safely accessed, decreases the total amount of this resource. Application of natural attenuation, alternate concentrations limits and institutional controls to ensure affected groundwater is not in appropriately accessed or used, allows the total volume of the resource to be preserved and allows those resources to be accessed outside the area of restricted use. The potential area of restricted access is already serviced by a municipal water supply. This irretrievable consumption of the groundwater resource from the shallow and intermediate groundwater systems in the arid west may be a non-trivial cumulative effect of the proposed and potential future corrective actions.

3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Land Use

When the Homestake mills were built, the surrounding area was generally remote ranch land with some irrigated land. In the 1960s and 1970s, several subdivisions were constructed in the vicinity of the mill, primarily by families working at the mill or in the area mines. HMC holds title to all lands within the GRP boundary and substantial amount of developed and undeveloped land around the GRP.

NRC License Condition 42 requires the submittal of a land use survey with the annual report (HMC and Hydro-Engineering, 2019). The general focus of the land use survey is to document and summarize the current land uses and any identified changes to land use in proximity to the GRP. In particular, land use activities for those areas proximal to the tailings pile areas undergoing reclamation and closure and immediate surrounding areas where ongoing ground-water restoration continues to be reviewed. The following sections describe the land uses in the area.

3.1.1 Land Use HMC Property

Homestake Mining Company of California (HMC) owns and controls a sizeable land area in and around the Grants Reclamation project. Over the last number of years, additional lands have been acquired as opportunity has arisen and acquisition of such lands are deemed appropriate in relation to ongoing ground-water remediation and restoration activities and final reclamation and closure of the GRP.

Areas that are in immediate proximity to the tailings pile complex and areas of active remediation have been, and continuing to be, restricted for any land use other than remedial action. Other land owned by HMC, not in the immediate proximity of areas of the tailings pile complex and active remediation, have allowed and continue to allow livestock grazing through lessor/lessee tenant arrangements. For example, the current land area within the immediate Site Boundary area containing the evaporation ponds, reverse osmosis treatment plant and both tailings pile areas and office / shop compound have been excluded from livestock grazing and other land use except those directly related to the ongoing groundwater restoration activities. These areas have been livestock fenced to exclude grazing; certain small areas in the southern and western portions of land outside of Site Boundary are, however, seasonally utilized for livestock grazing.

Several small lot or small acreage parcels held by HMC in the general area of the reclamation site are idle and are essentially not in use except in certain instances where treated and/or fresh water injection and water collection is underway as part of the ongoing groundwater restoration program or are under agricultural use on selected lot(s). For example, Block 1 Lot 5 and Block 2 Lot 2 in Murray Acres (Figure 3-1) were planted and irrigated in 2008 through 2018 with the Murray Acres San Andres irrigation well (806R).

The other significant past land use activity situated on HMC-held lands in the area includes land treatment and crop irrigation utilized for crop production. Water used for irrigation was an integral part of the historical groundwater restoration and cleanup program for the project. Prior to 2002, HMC had 270 acres of land under irrigation consisting of flood irrigation area comprising 120 acres and a center pivot spray irrigation area comprising 150 acres. During 2002, an additional center pivot irrigation system was commissioned that comprises 60 acres. In 2003, an additional 24 acres of flood irrigation was added to the irrigation system in Section 33. In 2005, the 60-acre center pivot irrigation system was expanded by 40 acres to a total of 100 acres (Figure 1-2). This land application process has been terminated and from 2013 through 2019, no HMC lands were irrigated except the two lots in Murray Acres where San Andres water is used (Figure 3-1).

3.1.2 Land Use Residential Subdivisions

The major land use immediately proximal to the GRP consists of residential development located in the Pleasant Valley Estates, Murray Acres, Broadview Acres and Felice Acres residential subdivisions (Figure 1-2). HMC provided these subdivision areas with a potable water supply system as an extension of the Village of Milan water supply in the mid-1980's. The Village of Milan water supply extension to these areas was provided at that time to address a concern over the quality of groundwater used for domestic purposes in these adjacent subdivision areas. HMC paid for the water usage from the Village of Milan for the first ten years and has re-started paying for the water usage in late 2018.

An assessment of current land use in these four subdivision areas was undertaken in January 2019 to provide an annual review of the present uses, occupancy and status for the various lots within these subdivisions. Over the years, permanent residential homes, modular homes and mobile homes have been established in the subdivision areas, and immediate adjacent areas, as would typify a rural residential neighborhood. A number of lots remain vacant, or are utilized for uses such as horse barns, corrals, equipment storage, etc. In some cases, dwellings are present on several lots throughout the subdivisions but are currently vacant or have been permanently abandoned and in various states of disrepair.

A lot-by-lot reconnaissance was made in each of the subdivisions to determine whether each lot was occupied or vacant and if it contained a residence(s) was the residence occupied. Results of this reconnaissance effort are summarized in Table 3-1.

3.2 Transportation

New Mexico State Highway 605 and Interstate 40 are the highway access routes near the GRP. The existing site transportation corridors are shown on Figure 3-2. The GRP is accessed from County Road 63. Site roads are predominantly dirt, unmaintained roads.

The nearest public use airport is the Grants-Milan Municipal Airport approximately five miles from the GRP. This airport can serve planes up to 30,000 pounds. The nearest airport that is served by major air carriers is in Albuquerque, New Mexico approximately 87 miles from GRP.

3.3 Cultural Resources

Cultural resource surveys were conducted at the site in 1993, 1994, 1995, 2006 and 2018 (SAC, 1993a, 1993b, 1994; CASA, 1994a, 1994b, 1994c, 1995; TEC, 2006). The extents of these surveys are shown on Figure 3-3. In 2017 and 2018, a cultural resource survey was completed on approximately 2,696 acres of the GRP (Lone Mountain, 2018) to survey areas not previously survey in preparation for GRP activities and eventual reclamation. All cultural surveys identified sites that were recommended eligible or had undetermined eligibility for nomination to the National Register of Historic Places.

The reports associated with these surveys recommended design of reclamation and corrective action activities to avoid the NRHP eligible sites and the sites with undetermined eligibility by at least 100 feet (ERM, 2018). Additionally, it was noted that if cultural deposits were encountered during site GRP activities, work should stop immediately, and the state archaeologist notified.

3.4 Geology and Soil

3.4.1 Geologic Setting

The Background Water Quality Evaluation of the Chinle aquifer report (HMC and Hydro-Engineering, 2003) summarizes the current understanding of the regional and local geologic conditions of the GRP. Figure 3-4 presents a portion of the geologic map of the San Mateo Creek Basin (Langman et al, 2012). This map shows the extent of bedrock, deposited from the Permian through the Tertiary, and overlying Quaternary alluvial deposits and volcanic flows. In general, progressively older units of Cretaceous through Permian bedrock outcrop from northeast to southwest as a result of regional deformation and subsequent erosion. The overlying Tertiary units consist predominantly of widely scattered Middle Tertiary (Pliocene and Miocene) andesite and basalt surficial flows related to the Mt. Taylor volcanic field cap. The Quaternary units consist of localized andesite and basalt flows and widespread alluvium, which is composed of eroded bedrock materials in the vicinity.

The GRP is located in the southeastern part of the Colorado Plateau physiographic province and is mostly on the south flank of the San Juan Basin. This region experienced a minor degree of structural deformation (Figure 3-5) consisting of regional folding and block uplift associated with formation of the Zuni Uplift, which is characterized by a northwest-trending anticline composed of Precambrian crystalline basement rocks overlain by Permian to Jurassic sedimentary rocks. These sedimentary rocks were uplifted during the Laramide Orogeny near the end of the Late Cretaceous through the Eocene, approximately 80 to 40 million years before present (ARCADIS, 2013). Bedrock units at the site, from oldest to youngest consist of the San Andres Limestone and Glorietta Sandstone and Chinle Formation. As a result of Laramide deformation, These bedrock units at the site dip to the northeast (Figure 3-6) at approximately 3 to 10 degrees (ARCADIS, 2013).

The development of more recent northeast-trending, high-angle normal faulting associated with the Rio Grande Rift resulted in minor fault displacements in this part of New Mexico. The San Mateo normal fault northeast of the site has a vertical displacement up to 450 feet (ARCADIS, 2013), as shown on Figure 3-5. Two small-scale normal faults in the vicinity of the site (known as the West Fault and East Fault) are shown on the U.S. Geological Survey geologic map of the Grants quadrangle (Figure 3-7). Evaluation of lithologic and geophysical logs from drilling investigations at the site indicate these two faults are located slightly farther to the west and to the east, respectively, than the locations shown on the USGS quadrangle map (Figure 3-8). Structural offset generally increases to the north along both faults (NRC, 2004). In general, these two faults are approximately vertical, shear is east side down, and are relatively impermeable barriers to groundwater flow within the permeable aquifers of the Chinle Formation near the GRP (ARCADIS, 2013). Except for the ends of the East Fault, the permeable sandstones of the Chinle Formation are adjacent to the relatively impermeable mudstones and siltstones across the two faults (ARCADIS, 2013). The offset of the underlying San Andres-Glorietta regional aquifer is much lower than the vertical thickness of the unit and does not appear to alter groundwater flow.

The Quaternary alluvium directly overlies the Chinle Formation and San Andres Limestone above a pronounced angular unconformity (Figure 3-9). As a result, sandstone units within the underlying Chinle Formation are abruptly truncated at the base of the alluvium. The Chinle Formation sandstone units are laterally continuous and separated by thick sections of low permeability shale. These geologic and hydrogeologic relationships are depicted in detailed hydrogeological cross-sections A-A' through D-D' (Figures 3-10 through 3-13).

Production of uranium started in the 1950s in the underground mines in the Ambrosia Lake area, which represented the majority of uranium ore production from this region (HMC, 2012). The ore- bearing rocks in this area consist primarily of Jurassic units that outcrop to the north of the GRP within the San Mateo

Creek and Lobo Creek alluvial drainages (Figure 3-1). The Quaternary alluvium in the GRP area was partly derived from the erosion of ore-bearing bedrock. As a result, the alluvium contains significant concentrations of naturally occurring uranium, as well as selenium and molybdenum, which are typically present in uranium deposits.

3.4.2 Geologic Units

The GRP is located in the southernmost part of the San Mateo Creek basing (Figure 3-4). Four sedimentary geologic units are present beneath the GRP. From youngest to oldest these units are alluvium, the Chinle Formation, San Andres Limestone and the Glorieta Sandstone. Four cross sections through the GRP were constructed with locations shown on Figure 3-8. Figures 3-10 through 3-13 present geologic cross sections through the GRP. As shown on the cross sections, the geologic units dip to the east-northeast. Two north-northeast-trending normal faults are present at the site, known as the East Fault and West Fault (Figure 3-8). These faults are approximately vertical and down-dropped on the east. The vertical displacement of the faults has juxtaposed the more permeable units of the Chinle Formation against less permeable mudstone layers, thus affecting the local flow regime. The San Andres Limestone and Glorieta Sandstone, although vertically displaced, maintain horizontal connectivity across the faults and flow is not affected.

3.4.2.1 Alluvium

Quaternary alluvium underlies the entire site, has variable hydraulic characteristics based on extensive testing, and is generally 50 to 100 feet thick.

HMC has drilled nearly 500 wells at the GRP. The geophysical and lithologic logs from these wells, as well as logs and information for residential wells not owned by HMC, have been used to define the base of the alluvium. The location of the alluvial wells that have been used to define the geology and ground water conditions in the alluvial aquifer at the GRP are shown on Figure 3-14.

The contours of the base of the alluvium are shown on Figure 3-15. The deepest portion of the alluvial aquifer is present below the western portion of the Large Tailings Pile. It turns to the southwest near the southwest corner of the Large Tailings Pile. The land surface elevation in this area is at approximately 6580 ft amsl, so the alluvium, at its thickest point, extends 120 feet below the ground surface.

The elevation of the base of the alluvium is shallower in an area extending from the eastern Murray Acres subdivision to the Small Tailings Pile. In this area, the alluvium is approximately 60 feet thick. The reduction in saturated thickness (Figure 3-16) and a generally lower permeability of the alluvial material in this area combine to decrease the rate of alluvial flow. The boundary of the alluvial aquifer is defined where the elevation of the base of the alluvium is equal to the water- level elevation (see green line on Figure 3-14).

3.4.2.2 Chinle Formation

The Chinle Formation is up to 900 feet thick at the GRP. The Chinle Formation is a massive dark reddish shale. Although the Chinle Formation is dominated by low-permeability shale units, beneath the GRP, the Chinle Formation contains three water-bearing units of relatively higher permeability. Sandstone units that are found within the Chinle Formation shale form the aquifers. These water-bearing units are referred to as the Upper Chinle Sandstone, Middle Chinle Sandstone, and Lower Chinle Mudstone. The extents of the Upper, Middle and Lower Chinle in the vicinity of the GRP are shown on Figure 3-17, 3-18, and 3-19, respectively.

3.4.2.3 San Andres Limestone and Glorietta Sandstone

The lowermost units of interest at the site are the San Andres Limestone and Glorieta Sandstone, which together are 200 to 225 feet thick. The San Andres Limestone and Glorieta Sandstone are overlain by an unconformity and underlain by the lower-permeability Yeso and Abo formations. The extent of the San Andres Limestone and Glorieta Sandstone in the vicinity of the GRP is shown on Figure 3-20.

3.4.3 Hydrogeology

3.4.3.1 Alluvial Aquifer

The alluvial aquifer is the principal unit of interest at the GRP. The alluvial aquifer is unconfined with saturated thickness ranging from zero to approximately 70 feet and is composed of three connected alluvial systems: San Mateo Creek, Lobo Canyon drainage, and Rio San Jose (HDR, 2016). The San Mateo Creek alluvium composes the north/northeastern branch and the central portion of the alluvial aquifer beneath the site, the Rio Lobo alluvium forms the eastern/southeastern branch of the alluvial aquifer, and the Rio San Jose alluvium forms the west-southwest portion of the alluvial aquifer (Figure 3-21). A local bedrock high causes the alluvial aquifer to branch to the west and south before the San Mateo Creek and Rio Lobo alluvial systems converge with the Rio San Jose alluvium.

The alluvial aquifer at the GRP is recharged from (1) upgradient inflows from the upper and middle San Mateo Creek basin, (2) surface streamflow infiltration losses and precipitation that collects in low-lying areas, (3) continued drain down of the Large Tailings Pile, (4) injection of treated groundwater and San Andres Limestone and Glorieta Sandstone groundwater through the site remediation system, and (5) discharge from the underlying Chinle and San Andres Limestone and Glorieta Sandstone aquifers at subcrops where heads in these aquifers are higher than alluvial aquifer heads. Discharge from the alluvial aquifer occurs by (1) pumping of contaminated groundwater to the treatment plants, (2) discharge to the underlying Chinle and San Andres Limestone and Glorieta Sandstone aquifers at subcrops where heads in the alluvial aquifer are higher than heads in these aquifers, and (3) groundwater outflow downgradient (south) of the GRP. Groundwater levels and flow directions within the alluvium are shown on Figure 13.

3.4.3.2 Chinle Formation Aquifers

The Chinle Formation in the vicinity of the GRP includes three water-bearing permeable sandstone horizons separated by shale, referred to as the Upper, Middle, and Lower Chinle aquifers. These aquifers are generally confined. The Chinle aquifers are generally recharged from (1) injection of treated groundwater and San Andres Limestone and Glorieta Sandstone aquifer groundwater through the site remediation system operations and (2) recharge from the overlying alluvial aquifer at subcrops where alluvial heads are greater than heads in the Chinle aquifers. Discharge from the Chinle aquifers occurs through (1) pumping of contaminated groundwater to the treatment plants, (2) discharge to the overlying alluvial aquifer at subcrops where heads in the Chinle aquifers are higher than alluvial heads, and (3) groundwater flow generally downdip away from the GRP to east-southeast.

3.4.3.3 San Andres Limestone and Glorieta Sandstone Aquifer

The San Andres Limestone and Glorieta Sandstone aquifer has a thickness exceeding 200 feet near the GRP and is the most significant regional aquifer in the area (HDR, 2016). As previously noted, the East and West faults do not displace the San Andres Limestone and Glorieta Sandstone enough to cause a lateral discontinuity. The San Andres Limestone and Glorieta Sandstone aquifer at the GRP is recharged from the overlying alluvial aquifer at subcrops where alluvial heads are greater than heads in the San Andres Limestone and Glorieta Sandstone. These subcrops are located to the west of the GRP in the area of the former Bluewater Mill site. Injection from the site remediation system is not occurring in the San Andres Limestone and Glorieta Sandstone. Discharge from the San Andres Limestone and Glorieta Sandstone aquifer occurs through (1) pumping of groundwater as a source of fresh water for use in the treatment plants' hydraulic containment system in the alluvial and Chinle aquifers, (2) discharge to the overlying alluvial aquifer at subcrops where heads in the San Andres Limestone and Glorieta Sandstone aquifer are higher than alluvial heads, and (3) groundwater outflow to the east-southeast. In the vicinity of the site, the primary interaction between the San Andres Limestone and Glorieta Sandstone and alluvial aquifers appears to be recharge of the San Andres Limestone and Glorieta Sandstone aquifer from the overlying alluvium, as evidenced by higher alluvial heads compared to San Andres Limestone and Glorieta Sandstone heads near the San Andres Limestone and Glorieta Sandstone subcrop.

3.4.4 Groundwater Flow

The groundwater potentiometric surface and flow direction in the alluvial aquifer and the Chinle Formation beneath the GRP is affected by groundwater extraction and injection. Groundwater levels and flow directions for the alluvial and Chinle aquifers are shown on Figures 3-22 through 3-25.

Water-level elevations and generalized flow directions for the San Andres Limestone and Glorieta Sandstone aquifer at the GRP in Fall 2016 are shown on Figure 3-26. The ambient flow direction in the San Andres Limestone and Glorieta Sandstone aquifer is to the east-southeast.

3.4.5 Soil

The Natural Resource Conservation Service Soil Map for was reviewed and twenty-one soil map units were identified within the one-mile buffer around the GRP (ERM, 2018). The Sparank-San Mateo complex was identified as the predominant soil type (Figure 3-27). Sparank and San Mateo soils are moderately alkaline and well drained. Sparank soil is clay loam overlying a silty clay loam and San Mateo soil is a loam (ERM, 2018).

3.5 Water Resources

3.5.1 Surface Water

The GRP area has very little surface water because of the limited rainfall and high evaporation rates in the region. Surface water in the immediate vicinity of the GRP is ephemeral and consists of the San Mateo and Lobo Creeks, and Rio San Jose. Surface flows in these creeks are virtually non-existent and may only occur for short periods of time in response to extreme snowmelt and/or summer thunderstorm events (Brown and Caldwell, 2018). During such events, the alluvial aquifer at the GRP is recharged from surface streamflow infiltration losses and precipitation that collects in low-lying areas. Maps showing upgradient drainage areas and surface water drainages in the vicinity of the GRP are presented in Figure 3-7 and Figure 1-1, respectively.

The San Mateo Creek watershed drainage covers an area of approximately 76 square miles and is part of the Rio Grande drainage basin (Byrd et al. 2004). The headwaters of San Mateo Creek are on the north flank of Mt. Taylor located approximately 15 miles east of the GRP. San Mateo Creek is intermittent over its middle reach, which is normally dry in the summer except for high rainfall events when runoff occurs and is ephemeral in its lower reach.

In the upper parts of San Mateo Creek and Lobo Canyon, on the western side of Mount Taylor, perennial flow occurs at San Mateo Springs, an unnamed tributary of San Mateo Creek, and an unnamed tributary of Lobo Creek. San Mateo and Lobo Creek Creeks both drain onto the GRP. Surface water discharges from the Lobo Canyon portion of the San Mateo watershed follow a drainage that cuts across the northeast corner of the former mill site. Two Lobo Creek drainages enter the east side of the GRP (Figure 1-1).

HMC constructed a diversion levee north of the former mill area to divert surface water flows from the northern branch of Lobo Creek (Figure 3-28 and Figure 3-29; AK Geoconsult and Jenkins, 1993). During flood events, the levee diverts Lobo Creek to the North Diversion Channel along the north edge of the Large Tailings Pile, preventing water from flowing across the former mill area. The levee was constructed using uncontaminated soils generally consisting of clayey sands and sandy clays. The slopes of the levee are protected against erosion using the same cover material specified for the Large Tailings Pile (HMC, 2013). San Mateo Creek drainage enters the GRP from the north (Figure 1-1) and is also diverted by the North Diversion Channel west around the Large Tailings Pile as shown on Figure 3-28.

3.5.2 Groundwater

Mining activities have affected groundwater quality in alluvium and bedrock aquifers in the vicinity of the GRP and surrounding mill sites (Figure 3-30). In the Ambrosia Lake area, direct discharge and surface infiltration of mine dewatering flows and seepage from unlined evaporation ponds has resulted in elevated concentrations of constituents in alluvial groundwater, including sulfate, uranium, radium, gross alpha, total dissolved solids (TDS), and selenium (Weston, 2016). Concentrations of these constituents have exceeded federal drinking water standards in both alluvial groundwater and within underlying bedrock units downgradient of historical mining and mill sites in the Ambrosia Lake area.

Activities at the former Bluewater Mill site affected groundwater within both alluvium, associated with the Rio San Jose, and the underlying San Andres Limestone and Glorieta Sandstone aquifer (DOE, 2014). Elevated levels of molybdenum, selenium, and uranium have been detected downgradient of the former Bluewater Mill site and historical tailings pond. Uranium has been identified as the primary constituent of concern, and uranium concentrations above the federal drinking water standard have been observed downgradient of the site.

Groundwater in the San Mateo Creek Basin is utilized for a variety of sources as discussed in the following sections.

3.5.2.1 Alluvium

Pumping from the alluvium occurs for domestic, stock, irrigation, and industrial purposes. Significant pumping and injection occur in the alluvium associated with remediation at the GRP, which have generally increased saturated thicknesses in the alluvium near the site. The 2018 groundwater potentiometric surface map is provided as Figure 3-22.

Historical mine dewatering pumping has had a significant long-term effect on groundwater flows in the alluvium in the SMC Basin. Mining of uranium occurred primarily in the Ambrosia Lake area of the SMC Basin. Groundwater extracted from mine dewatering was either used in the mine process or discharged to local drainages or the ground surface (NMONRT, 2010). Much of this discharge flowed to the Arroyo del Puerto and recharged local alluvium. Alluvium in this area was likely unsaturated prior to mining (DOE, 1996; Maxim, 2000; Weston, 2016). As such, most of the groundwater in alluvial sediments in the Arroyo del Puerto currently is a result of past mining activities and is not naturally occurring. Recharge of mine dewatering discharge over an approximately 25-year period resulted in increased flow downgradient in the Arroyo del Puerto and ultimately San Mateo Creek.

Water levels, in a GRP alluvial located approximately one-mile upgradient (north) of the GRP, show a continuous increasing trend in water levels, from an elevation of approximately 6,548 feet above mean sea level (ft amsl) in early 1976 to 6,564 ft amsl in late 2016. The slow, rise in alluvial groundwater levels (approximately 2.7 feet per year) over several decades is interpreted as the result of slow groundwater movement downgradient of historical mine and remediation discharges at the GRP to the alluvium of San Mateo Creek.

3.5.2.2 San Andres Limestone and Glorieta Sandstone

The San Andres Limestone and Glorieta Sandstone aquifer represents the primary groundwater aquifer in the region surrounding the GRP and has historically been subject to significant pumping for irrigation, municipal, mining, and industrial water supplies. Long-term pumping from the aquifer has resulted in localized drawdown and changes in groundwater flow conditions (Baldwin and Anderholm 1992). Data on historical pumping for irrigation are limited. Frenzel (1992) provides estimates for irrigation pumping from the early 1900s through 1985 based on streamflow data, acres of irrigated fields, and pumping records where available. Total irrigation pumping in the Bluewater-Toltec area was estimated to range between 3,500 acre-feet (ac-ft) per year in 1945 to a maximum of 12,600 ac-ft per year in 1954. Irrigation pumping declined to near zero after 1980 (Frenzel, 1992). Figure 3-31 presents Frenzel's estimate of groundwater pumped for irrigation use between 1900 and 1990.

Frenzel (1992) provides tables estimating total pumping rates from municipal and industrial sources through the late 1980s. Municipal pumping, primarily from the city of Grants, increased from 200 ac-ft per year in 1945 to more than 3,000 ac-ft per year in 1980. Pumping from industrial sources in the San Andres Limestone and Glorieta Sandstone aquifer, primarily from mining and uranium mills (including HMC), ranges from 75 ac-ft per year in 1952 to a peak of 2,500 ac-ft per year in 1957. Figure 3-32 presents graphs showing municipal and industrial pumping from the San Andres Limestone and Glorieta Sandstone aquifer through the late 1980s (Frenzel, 1992).

3.5.2.3 Groundwater Use

Groundwater from residential private wells was used in the past for garden irrigation and possibly domestic uses such as drinking, cooking, showering, and washing. Mitigation of potential exposure to GRP-impacted groundwater by nearby residents was initiated in 1975 and continues today.

In 1983, HMC signed an agreement with EPA that required HMC to provide an extension of the Village of Milan municipal water system to four residential subdivisions south and southwest of the former mill site which were in the impacted groundwater area. Per the 1983 agreement, HMC paid for the resident's water use for a period of 10 years. The connection of the subdivision residences to the Village of Milan's water supply was completed in 1985. HMC began paying for water usage again in late 2018.

In 2009, NMED issued a health advisory intended to minimize the possibility of new wells being installed within the area of contamination. The health advisory was published in two newspapers of general circulation in Cibola and McKinley Counties. Also, NMED required the New Mexico Office of State Engineer to provide a copy of the health advisory to every person who applied for a well permit within the area referenced in the drinking water advisory.

On May 2, 2018 the Office of the State Engineer issued an Order restricting well drilling in the alluvial and Chinle aquifers within an area where groundwater is impacted by historical uranium milling and mining activities. The purpose of the Order is to protect human health and prevent interference with groundwater flow associated with ongoing remediation. The Order restricts the permitting and drilling of wells for new appropriations, or replacement or supplemental wells, and restricts the permitting of any change to the point of diversion of any existing wells within the boundaries defined. This moratorium excludes permit applications that are submitted on behalf of NMED or that may be required for remedial action and monitoring and excludes areas within the NRC licensed boundaries for the HMC and Bluewater sites. The Order will be in effect in perpetuity or until groundwater concentrations decrease to levels less than Water Quality Control Commission standards in 20.6.2.3103 New Mexico Administrative Code (NMSEO, 2018). Figures 3-33 and 3-34 present the boundaries of the areas of the alluvial and Chinle aquifers, respectively, where use of the groundwater is restricted, as discussed above.

The GRP uses bottled water for drinking. The GRP also uses water from a production well completed in the San Andreas Limestone and Glorieta Sandstone aquifer for other domestic and sanitary uses. Deed restrictions will be put in place for HMC's former land treatment areas that will prohibit residential and agricultural use of the land treatment areas and use of groundwater for drinking beneath land treatment areas.

As an annual reporting requirement in the 2009 Memorandum of Understanding with NMED (HMC and NMED, 2009), HMC determines if any new wells have been installed within the area of contamination, reports the findings in the annual report, and allows any resident in a designated area of concern who is not on the Village of Milan water supply the opportunity to be hooked up to the municipal water system at HMC's expense. Based on the results of the 2018 annual survey, all water users in the area of concern are supplied by the Village of Milan water supply, except one Valle Verde residence who has now stated an interest in having a connection to the Milan water system (HMC and Hydro-Engineering, 2019).

3.5.2.4 Groundwater Quality

The NRC and NMED have set GRP groundwater protection standards based on the background water quality and accordingly amended the Radioactive Material license and DP-200 to reflect those standards (Table 1-1). Groundwater quality in the alluvium, the Upper Chinle and the Middle Chinle units have been affected by mill-derived constituents above the GRP groundwater protection standards.

The primary sources of groundwater contamination at the GRP are the Large and Small Tailings Piles (HDR, 2016). Historical seepage of process-water-bearing uranium and other trace radioactive and non-radioactive constituents resulted in loading of these metals to alluvial groundwater beneath the tailings piles. The extent of contamination in the alluvial and Chinle aquifers at the end of 2018, based on uranium concentrations exceeding the current GRP groundwater protection standards is shown on Figures 3-35 through 3-38. Groundwater contamination from the GRP has not been detected in the San Andres Limestone and the Glorieta Sandstone aquifer (Figure 3-39). Substantial progress in reducing constituent concentrations has been made in the alluvial and Chinle water-bearing zones since remediation activities began in the 1980s.

In the alluvial aquifer, groundwater concentrations exceed uranium GRP groundwater protection standards (1) beneath the tailings piles, (2) in western and southern plumes emanating from the tailings pile area, and (3) in an apparently isolated plume south of Felice Acres resulting from continuity with impacted groundwater in the Large Tailings Pile area through the Upper Chinle aquifer and possibly through the alluvium. (Figure 3-35).

In the Upper Chinle aquifer, groundwater concentrations exceed the uranium GRP groundwater protection standards (1) beneath the Large and Small Tailings Piles and (2) near Broadview and Felice Acres (Figure 3-36). In the Middle Chinle aquifer, groundwater concentrations exceed uranium GRP groundwater protection standards (1) near the subcrop west of the West Fault and (2) near Broadview and Felice Acres (Figure 3-37).

3.6 Ecological Resources

When the HMC mill and tailings piles were constructed in 1956 to 1958, no ecological surveys of were performed before disturbance. Recently, a survey was conducted in 2018 with a one-mile buffer around the GRP as shown in Figure 3-40 (ERM, 2018).

The vegetation communities near the GRP are Inter-Mountain Basins Mixed Salt Desert Shrub and Inter-Mountain Basins Semi-Desert Grasslands with minor areas of Inter-Mountain Basins Semi-Desert Shrub Steppe (ERM, 2018). Developed and disturbed areas and cultivated cropland is also present at and in the vicinity of the GRP. The vegetation communities are shown on Figure 3-41. A lack of aquatic or diverse riparian habitat was not present and therefore the associated aquatic and riparian species would not be present in the one-mile buffer around the GRP (ERM, 2018).

The survey (ERM, 2018) identified several plant and wildlife species of interest (Tables 3-2 and 3-3). No federal or state threatened or endangered species were observed on site. However, suitable habitat exists within one mile of the GRP for the peregrine falcon and the gray vireo, federal threatened and state threatened species, respectively. The loggerhead shrike, a New Mexico sensitive and federal bird of conservation concern was observed during the survey. Habitat for other federal birds of conservation concern and New Mexico sensitive species and crucial habitat for elk, cougar, and mule deer were identified within the one-mile buffer around the GRP (Table 3-3 and Figures 3-42 through 3-45).

The USFWS online threatened and endangered species list identified no crucial habitats within the area identified near the GRP (Appendix A).

3.7 Meteorology, Climatology and Air Quality

3.7.1 Regional Climate

The climate of western New Mexico is generally a mild, arid to semi-arid, continental climate characterized by low precipitation, abundant sunshine, low relative humidity, and a large annual and diurnal (day and night) temperature range. Temperature and precipitation are largely controlled by elevation and slope aspect. Summer rains fall almost entirely during brief, but frequently intense thunderstorms. The general southeasterly circulation from the Gulf of Mexico brings moisture for these storms into New Mexico, and strong surface heating combined with orographic lifting as the air moves over higher terrain causes air currents and condensation. July and August are typically the rainiest months, with from 30 to 40 percent of the year's total moisture falling at that time. Winter precipitation is caused mainly by frontal activity associated with the general movement of Pacific Ocean storms from west to east. As these storms move inland, much of the moisture is precipitated over the coastal and inland mountain ranges of California, Nevada, Arizona, and Utah. Winter is the driest season in New Mexico. Much of the winter precipitation falls as snow in the mountain areas, but it may occur as either rain or snow in the valleys (NMSU, 2019).

3.7.2 Local Meteorology and Climate

The GRP has an arid to semi-arid, temperate climate typical of a high desert. Table 3-4 summarizes the average monthly temperature and precipitation at the Grants Airport located about 5.5 miles south of the site. Average temperatures range from a low of about 14 degrees Fahrenheit (°F) in January to a high of 89°F in July. The average annual precipitation is approximately 10 inches per year. Most of the precipitation, about 60 percent or 6 inches, falls in late summer and early fall. Average precipitation for the remainder of the year is about 0.5 inches per month.

HMC maintains a meteorological station at the GRP that is equipped to measure horizontal wind speed and direction at 10 meters above ground level, temperature, solar radiation and relative humidity at 9.5 meters above ground level, barometric pressure at 8.8 meters above ground level, and precipitation at 0.4 meters above ground level. A summary of the HMC site meteorological data for 2018 is provided as Table 3-5.

The minimum and maximum temperatures measured at the GRP in 2018 ranged from 1°F to 93°F. The annual precipitation measured at the GRP in 2018 was 7.38 inches. The average pan evaporation at Laguna, New Mexico, about 30 miles southeast, for the period 1914-2005 (WRCC, 2019) is approximately 63 inches per year, resulting in an annual moisture deficit for the region. Evaporation is highest in June and July as shown in Figure 3-46**.**

Wind speed and direction measured hourly at the GRP meteorological station are shown as a wind rose for 2018 in Figure 3-47. Prevailing winds faster than 2.1 meters per second are from the west and northwest, consistent with regional prevailing northwesterly winds reported at the Grants Airport. The strongest winds are from the west and southwest and are associated with frontal systems moving from the Pacific Ocean. Moderate winds from the south-southeast are associated with summer storms from the Gulf of Mexico. Most of the light northeasterly breezes occur at night.

3.7.3 Air Quality

No known monitoring stations are near the GRP. The nearest monitoring stations are outside of Albuquerque in Los Lunas and Bernalillo (http://nmaqinow.net, February 2019). Local sources of total suspended particulates are windblown dust, windblown water particles from the aeration systems on the evaporation ponds and vehicles on unpaved roads.

3.8 Noise

The GRP is one half to three quarters of a mile from the nearest resident. Noise generated at the GRP is from vehicle traffic, pump operation, and monitoring well drilling activities. No sensitive noise receptors (e.g., schools and hospitals) are known to be located near the site.

3.9 Historic and Cultural Resources

When the HMC mill and tailings piles were constructed in 1956 to 1958 no surveys of historical and cultural resources were performed before disturbance. Since that time several historic and cultural surveys have been conducted (Figure 3-3). Most recently a survey was conducted in 2018 with a one-mile buffer around the GRP as shown in Figure 3-3 (ERM, 2018).

3.10 Visual and Scenic Resources

The buildings of the GRP are visible from County Road 63 and State Highway 605. Additionally, the site facilities are visible from the nearby subdivisions. The El Malpais National Monument is within 30 miles of the GRP. United States Forest Service national forests are located approximately two to five miles east and southwest of the GRP.

3.11 Socioeconomic

The population of New Mexico in 2010 was 2,389,039 (census.gov, 2019). This population represents an overall density of 29 persons per square mile (mi2) or 8.9 persons per square kilometer (km^2).

Cibola County is approximately 4,542 square miles in size and the population was estimated to be 26,746 in 2019 (https://www.census.gov/quickfacts/cibolacountynewmexico). The University of New Mexico Geospatial and Populations studies estimated the population to be 27,103.32 in 2018. That is approximately six people per square mile. The population of Cibola County declined 1.7 percent between 2010 and 2018 (census.gov).

The median household income for 2014 to 2018 in Cibola County was $37,368 with approximately 28 percent of the population living in poverty. Available information for Milan, Grants, and San Rafael, near the GRP is provided in Table 3.6.

3.12 Public and Occupational Health

As presented in the 2018 Annual Report, the calculated annual total effective dose equivalent (TEDE) for occupational exposure was 53 mrem of which approximately 40 mrem was attributable to airborne particulates and radon decay products (HMC and Hydro-Engineering, 2019). Optically Simulated Luminescent (OSL) badges were utilized to measure the maximum quarterly occupational radiation deep dose for 2018. It was measured to be 4 mrem. The 2018 Annual Report reported that "*nearly all the badges show doses below the reporting limit of 1 mrem in a quarter*" (HMC and Hydro-Engineering, 2019). Internal dose calculations were not available at the time of the 2018 Annual Report.

As discussed in Section 2, air particulate and radon concentrations and direct gamma radiation dose are measured at the GRP boundary and at identified locations for the nearest resident (Figure 1-3). The 2018 calculated TEDE public dose assumed 75 percent total occupancy with 200 equivalent days per year indoors and 71 days per year outdoors. The public dose was calculated as 52 mrem/yr and 50 mrem/yr at HMC-4 and HMC-5, respectively. The 2018 Annual Report stated that "*The doses from inhalation of radionuclides in airborne particulate material are negligible at the nearest residences. The calculated doses are well within the 10 CFR 20.1301(a)(1) public dose limit of 100 mrem per year and the doses from airborne radionuclides, excluding radon, meet the ALARA constraint limit of 10 mrem per year (10 CFR 20.1101(d))* (HMC and Hydro-Engineering, 2019). Eighty percent of the TEDE public dose was attributable to radon and direct radiation accounting for twenty percent.

3.13 Waste management

Historical mill tailings and other 11e.(2) Byproduct Material wastes were placed in the Large Tailings Pile and Small Tailings Pile. Since milling was terminated, the processing facilities decommissioned and placed into the Small Tailings Pile, the principal waste management facilities are the radioactive waste disposal areas in the Small Tailings Pile (as outlined in SOP 22) and the evaporation ponds. EP-1 is a single lined impoundment approximately 30 acres in area located on the Small Tailings Pile (Figure 2-11). EP-2 is a double lined impoundment approximately 19 acres in area located due west of EP-1 (Figure 2-11). EP-3 is a double lined impoundment of approximately 26 acres located north of the Large Tailings Pile (Figure 2-11). Two single lined collection ponds are located due east of the RO Plant (Figure 2-11). Non-compliant water (water pumped for corrective action but not meeting compliance limits in License Condition 35B) and solid effluents from the treatment systems are discharge to the East and West Collection Ponds, where solids settling occurs. Collected waters are then pumped to the evaporation ponds for management and disposal through evaporation. Solids retained in the collection ponds are periodically excavated form the collection ponds and placed in EP-1 for long-term disposal. All collection ponds and evaporation ponds will be decommissioned and reclaimed within the Small Tailings Pile upon approval for termination of groundwater corrective actions as required by the approved Decommissioning and Reclamation Plan.

4.0 ENVIRONMENTAL IMPACTS

4.1 Land Use Impacts

The proposed action continues the current groundwater restoration activities. There are no current land use restrictions within the GRP boundary. Most of the current land within the GRP boundary has been excluded from livestock grazing and other land uses.

4.2 Transportation Impacts

No additional construction or infrastructure is planned for the Proposed Action, current groundwater restoration activities will continue for ten years. The proposed action will not add to transportation requirements or number of vehicle trips to and from the GRP each year. Transportation to and from the GRP will primarily involve commuting GRP personnel and service providers, as well as delivery of consumable items such as diesel fuel, reagents, PPE, and other materials associated with operating the GRP.

Only uncontaminated domestic waste and materials or decontaminated materials meeting unrestricted release criteria will be transported off the GRP. The primary modes of transportation are automobiles and trucks.

4.3 Geology and Soils Impacts

The proposed action continues the current groundwater restoration activities. No additional construction work is anticipated and no impacts to geology and soil are expected.

4.4 Water Resources Impacts

The proposed action continues the current groundwater restoration activities and will increase the amount of water injected and removed from the aquifers. The proposed action will continue to remove groundwater from the aquifers for approximately ten years. Of all the water pumped for remedial actions, approximately 80 percent will be returned to the aquifer as treated and compliant effluent. These withdrawals from the alluvial and Chinle aquifers are not anticipated to have any local adverse effects on agricultural, industrial, or permitted residential water uses, which are very limited in the local area. However, an additional ten years of pumping will permanently remove through evaporation between 1,400,000,000 to 1,800,000,000 gallons of water.

4.5 Ecological Resources Impacts

The proposed action continues the current groundwater restoration activities and involves no additional surface disturbance. The proposed action will have high salinity evaporation ponds open for at least twelve years. Waterfowl and other wildlife may be exposed to the high salinity of these ponds.

4.6 Air Quality Impacts

The proposed action continues the current groundwater restoration activities with no appreciable change in sources of emissions.

4.7 Noise Impacts

The proposed action continues the current groundwater restoration activities and there will be no increase in noise as a result of the ongoing activities. Operation of enhanced evaporation devices (ie., TurboMisters) on the evaporation ponds are limited to daylight operating hours and operating noise levels at the margins of the ponds are below 90 decibels.

4.8 Historic and Cultural Resources Impacts

The proposed action continues the current groundwater restoration activities and involves no additional surface disturbance. No impacts will be associate with cultural resources.

4.9 Visual/Scenic Resources Impacts

The proposed action continues the current groundwater restoration activities and involves no additional surface disturbance or additional building. No appreciable impacts to visual or scenic resources are expected.

4.10 Socioeconomic Impacts

The proposed action continues the current groundwater restoration activities and no changes to community, social, political or economic systems will occur.

4.11 Environmental Justice

The proposed action continues the current groundwater restoration activities and there are no data to indicate that the proposed action or the alternatives would unfairly impact a specific population based on race, color, national origin, or income. Therefore, no potential adverse impacts related to environmental justice are identified.

4.12 Public and Occupational Health Impacts

The proposed action continues the current groundwater restoration activities. No measurable change to 77radon, airborne particulate or gamma radiation exposure is anticipated because the activities at the GRP will remain unchanged. A radiation protection program is maintained at the GRP. The 2018 Annual Report stated that "t*he calculated doses are well within the 10 CFR 20.1301(a)(1) public dose limit of 100 mrem per year and the doses from airborne radionuclides, excluding radon, meet the ALARA constraint limit of 10 mrem per year (10 CFR 20.1101(d))* (HMC and Hydro-Engineering, 2019).

4.12.1 Nonradiological Impacts

The proposed action will substantially decrease the dissolved mass of non-radiological hazardous constituents in the groundwater systems of the alluvial aquifer and the Chinle Formation. As a result, the area over which groundwater concentrations exceed the protective limits identified in License Condition 35B will be substantially reduced.

4.12.2 Radiological Impacts

No radiological hazardous constituents are present in the groundwater system outside the GRP boundary. The proposed action includes pumping and restoration actions for areas both outside the GRP boundary and within the GRP Boundary. Within the GRP boundary, near the Large Tailings Pile and Small Tailings Pile which have radiological hazardous constituents above limits in License Condition 35B, the proposed action will reduce the mass of radiological hazardous constituents in groundwater and the extent over which they exceed protective limits. No adverse radiological impacts from the proposed action are anticipated.

The proposed action will substantially decrease the dissolved mass of non-radiological hazardous constituents in the groundwater of the alluvial aquifer and the Chinle Formation. As a result, the area over which groundwater concentrations exceed the protective limits identified in License Condition 35B will be substantially reduced.

4.13 Waste Management

The proposed action continues the current groundwater restoration activities. The ten-year duration of the proposed action will result in the generation of between 1,400,000,000 and 1,800,000,000 gallons of non-compliant effluent for management in the evaporation ponds. In addition, ten additional years of water treatment will result in 349,000 tons of water treatment solid wastes that will be disposed in the Large Tailings Pile. No additional waste management facilities will be required to manage these wastes, which are the same wastes currently produced and managed as part of the licensed corrective action program. Therefore, there are no adverse impacts associated with waste management anticipated form the proposed action.

5.0 MITIGATION MEASURES

Two areas of potential impact are identified in Section 4, above. The impacts relate to the irrevocable commitment of between 1,4000,000,000 and 1,800,000,000 gallons of water lost to evaporation from the local groundwater systems and to the potential for continued ecological exposure of birds and waterfowl to the brine water of the evaporation ponds for an additional ten years of operation.

Reinjection of over 80 percent of the extracted water will, in part mitigate the groundwater withdrawals. However, because no adverse impact to the local industrial, agricultural or permitted residential use of alluvial or Chinle Formation groundwater is anticipated, no mitigation is proposed. The evaporation of between 1,4000,000,000 and 1,800,000,000 gallons is considered an irrevocable commitment of the water resource.

Mitigation of wildlife exposures in the ponds is ongoing. Mitigation measures include placement of reflective ribbon on T-posts and placement of predatory decoy birds (i.e., falcons and owls) around the pond perimeters to create visual deterrents for bird use of the ponds. Best management practices will continue to be implemented to ensure no adverse impacts to the other environmental media or receptors occurs under the proposed action. Section 6.2 discusses ecological monitoring for the ponds.

6.0 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

HMC has been monitoring groundwater quality at the GRP since 1961 when contamination was first discovered (Chavez 1961). Under the proposed action, compliance, corrective action, and operational groundwater monitoring will continue be conducted at the GRP to satisfy the requirements of 10 CFR 40 Appendix A, Criterion 7A and to evaluate the performance and effectiveness of the proposed action. The overarching GCAP requirement as outlined in 10 CFR 40 Appendix A, Criterion 5D is to implement the proposed action that will ultimately meet the limits specified in License Condition 35B within a reasonable timeframe. Groundwater monitoring will be conducted in accordance with the Groundwater Monitoring Plan approved by the NRC on November 12, 2019 (NRC, 2019) and incorporated as Radioactive Materials License SUA-1471 License Amendment 55, Condition 35A.

6.1 Radiological Monitoring

6.1.1 Air Particulate Monitoring

The GRP continuously samples total suspended particulates at seven locations around the reclamation site (Figure 1-3). Those locations identified as HMC-1, HMC-lA, HMC-2 and HMC-3 are areas at the property boundary expected to have the highest predictable concentrations of airborne radioactive particulates. The predominant wind direction is from the southwest; accordingly, HMC-1, HMC-2 and HMC-3 are generally located downwind from Homestake's reclamation activities. HMC-lA is northeast of EP-3 located north of the mill site. The location identified as HMC-6 represents background conditions for air particulates and is located due west of the large tailings pile at the western most side of the property boundary. Locations HMC-4 and HMC-5 are site proximal to the nearest residences. HMC-7 is a blank Whatman filter that is analyzed as a lab and filter manufacturer quality check sample.

Homestake uses Hi-Q HVP-4300 AFC High Volume Air Samplers (or equivalent) to continuously sample the ambient air at the locations shown in Figure 1-3. The samples are collected on 8-inch by 10-inch Whatman glass fiber filters (or equivalent), which are changed weekly or more frequently as required by dust loading. The collected samples are composited quarterly and analyzed for natural Uranium, radium-226 and thorium-230. Air sampling flow volumes and run times are recorded by HMC and the data are reported to the laboratory for calculation of average radionuclide concentrations in air particulates.

6.1.2 Radon Monitoring

Radon-222 gas concentrations in ambient outdoor air are monitored on a continuous basis at the nine locations identified in Figure 1-3. The background location for radon gas is HMC-16, located northwest of the site. Rapidos high-sensitivity track-etch passive radon monitors (PRM) from Radonova (formerly Landauer Radon), or equivalent, are used to continuously monitor radon gas at each sampling location. Homestake personnel place new PRMs quarterly at the monitoring locations and the exposed detectors are retrieved and returned to the vendor for analysis. The PRM detectors measure radon gas concentrations in ambient outdoor air by exposing a special alpha-particle sensitive plastic chip mounted inside a chamber with a membrane filter on one end that is permeable to air and radon gas, but not to dust or solid phase particulate radionuclides. Radon-222 gas from ambient air diffuses through the membrane, and the subsequent decay of radon gas inside the chamber causes imprint tracks on the alpha- sensitive plastic chip that can be enhanced by a chemical etching process and counted after collection. The radon gas concentration is calculated by determining the number of tracks per unit area of the plastic chip.

6.1.3 Radon Flux Monitoring

Regulations in 10 CPR 40.65 require licensees to estimate and report the quantities of principal radionuclides released to unrestricted areas in gaseous effluents every six months.

Radon-222 is typically the only gaseous-phase effluent radionuclide released to unrestricted areas. The principal sources of radon-222 at the site are the large tailings pile (LTP) and Small Tailings Pile (STP). Radon-222 releases from components of the water treatment system (the reverse osmosis treatment plant and evaporation ponds) are insignificant relative to those of the Large Tailings Pile and Small Tailings Pile.

Annual flux measurements occur in the fall as two separate deployments, consisting of 100 canisters per deployment on the Large Tailings Pile and Small Tailings Pile respectively. Deployments are conducted in accordance with the methods proposed in HMC's response to the NRC's 2017 notice of violation (NOV) regarding an average radon flux rate from the Large Tailings Pile that exceeded the 20 pCi/m-s standard given in 10 CPR 40, Appendix A (ERG, 2017 and NRC, 2017).

On April 20, 2017, the NRC issued a notice of violation for the manner in which average radon flux was measured and calculated for 2015. The 2016 annual flux report, dated January 2017, observed previously existing protocols pending NRC resolution of a regulatory decision on these matters. On April 24-26 2017, the NRC conducted an onsite inspection, and in associated discussions indicated that side slopes of the Large Tailings Pile, upon which final cover was completed in 1995 (including flux measurements followed by placement of final erosion control material), cannot be used for annual flux estimates unless new flux measurements on the side slopes are conducted. NRC indicated that 100 annual measurements across the top of the Large Tailings Pile, and calculation of the arithmetic mean of the 100 measurements, would be an acceptable approach to meet the requirements of License Condition 36(E) with respect to the Large Tailings Pile. This protocol was observed for 2017 and 2018 annual radon flux measurements as detailed in respective radon flux reports provided in corresponding semi-annual environmental monitoring reports.

6.1.4 Direct Radiation

Gamma dose rates are continuously monitored using optically stimulated luminescence (OSL) dosimeter badges placed at each of the eight locations identified in Figure-1-3. HMC-16 is considered the background location for direct radiation. Each OSL badge consists of an aluminum oxide detector within a plastic holder. The plastic provides adequate protection from weather for these badges to be used outdoors. The OSLs are exchanged semi-annually and analyzed by an approved independent laboratory. The levels of direct environmental radiation are recorded for each of the eight locations.

6.1.5 Surface Contamination

The Occupational Monitoring Program requirements are summarized in Table 3-7. The monitoring of personnel for alpha contamination may be required by the Radiation Safety Officer depending on the nature of the work being performed as specified in the Radiation Protection Program Manual (HMC, 2018b). The applicable procedure is found in SOP 12 (Contamination Surveys) which may or may not be conducted under a radiation work permit at the discretion of the Radiation Safety Officer. Documentation for personnel contamination surveys is maintained in each specific RWP documentation binder or in a binder for miscellaneous surveys as applicable.

Equipment surveys are required for all equipment that is to be removed from Restricted Areas as specified in the Radiation Protection Program (HMC, 2018b). Standard Operating Procedures are used for these surveys.

6.2 Ecological Monitoring

Wildlife surveys of the evaporation ponds are conducted according to SOP 30. If wildlife is identified on the ponds, the presence of wildlife and the measure taken to deter wildlife from the ponds are noted on the Wildlife Observation and Dispersal Form. Any bird death is reported to State of New Mexico.

7.0 COST BENEFIT ANALYSIS

Capital costs for Alternative 1 include decommissioning and demolition of the existing water treatment systems and installation of the final cover, which includes decommissioning and demolition of the reverse osmosis and zeolite treatment system, well abandonment, and construction of the cover. Annual and periodic costs include groundwater monitoring and reporting. Estimated costs for Alternatives 1 through 3 are presented in Appendix F of the GCAP (HMC, 2019) and summarized in Table 7-1. A discount rate of 13 percent was used to calculate the net present value (NPV).

The total estimated cost for implementing Alternative 1 in the first two years is approximately $13 million, with an anticipated total remedy cost of $65 million (current dollar) and $24 million NPV.

Operation, maintenance, and monitoring of the groundwater containment and recovery system (Alternative 2) are the primary costs in the short term at a rate of approximately $10 million per year that decreases to $8 million per year by the end of the assumed operation period of 24 years. Significant capital costs are anticipated after 24 years for decommissioning and demolition of the existing water treatment systems and installation of the final cover, which includes decommissioning and demolition of the reverse osmosis and zeolite treatment systems, well abandonment, and construction of the cover. Other annual and periodic costs include groundwater monitoring and reporting. The total estimated cost for implementing Alternative 2 through Year 20 is approximately $215 million, with an anticipated total remedy cost of $264 million (current dollar) and $87 million (NPV).

The primary short-term costs of Alternative 3 are the operation, maintenance, and monitoring of the groundwater containment and recovery system for ten years immediately followed by the installation of the PRBs. Significant capital costs are also anticipated after ten years for decommissioning and demolition of the existing water treatment systems and installation of the final cover, which includes decommissioning and demolition of the reverse osmosis and zeolite treatment systems, well abandonment, and construction of the cover. Costs to expand the PRBs to add and extend groundwater treatment capacity are included in Year 25. Other annual and periodic costs include groundwater monitoring and reporting. The total estimated cost for implementing Alternative 3 through Year 20 is approximately $135 million.

Alternative 1 has the lowest total and NPV costs at $65 and $24 million, respectively, at Year 30. Both Alternative 2 and Alternative 3 would require substantial expenditures related to increasing the volume of treatment not accounted in the alternative assessment. Alternatives 2 and 3 have similar total costs ($152 and $120 million) and NPV costs ($75 and $67 million) through Year 12 after which annual costs for Alternative 3 (2 million/year) are four times less than Alternative 2 (8 million/year) since operation of the groundwater system is stopped and the initial PRBs are constructed. Through Year 30, the estimated total cost for Alternative 3 ($162 million) is $102 million less than Alternative 2 ($264 million). The difference in NPV between Alternatives 2 ($87 million) and 3 ($70 million) through Year 30 is $17 million.

The sizes of the 50-Year uranium plumes modeled for each alternative are provided in Table 7-2. The cost of improved land with water rights is estimated to be $50,000 per acre and unimproved land with water rights is estimated to be $3,000 per acre. If the difference between the uranium plume in the alluvial aquifer outside the GRP boundary in Alternative 1 and Alternative 2 is 637 acres, and the cost of that unimproved acreage with associated water rights is $3,000 per acre, then the benefit of recovery of that affected land in Alternative 2 over Alternative 1 is $1,911,000. If the acreage were improved, then the benefit of recovery of that acreage would be $31,850,000.

If the difference between the uranium plume in the alluvial aquifer outside the GRP boundary in Alternative 1 and Alternative 3 is 413 acres, and the cost of that unimproved acreage with associated water rights is $3,000 per acre, then the benefit of recovery of that affected land in Alternative 3 over Alternative 1 is

$1,239,000. If the acreage were improved, then the benefit of recovery of that acreage would be $20,650,000.

If the difference between the uranium plume in the Upper Chinle aquifer outside of the GRP boundary in Alternative 1 and Alternative 2 is 13 acres, and the cost of that unimproved acreage with associated water rights is $3,000 per acre, then the benefit of recovery of that affected land in Alternative 2 over Alternative 1 is $39,000. If the acreage were improved, then the benefit of recovery of that acreage would be $650,000.

If the difference between the uranium plume in the Upper Chinle aquifer outside of the GRP boundary in Alternative 1 and Alternative 3 is 12 acres, and the cost of that unimproved acreage with associated water rights is $3,000 per acre, then the benefit of recovery of that affected land in Alternative 3 over Alternative 1 is $36,000. If the acreage were improved, then the benefit of recovery of that acreage would be $600,000.

8.0 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

As this proposed action addresses very local groundwater resources with an existing alternative domestic water supply provided by the local municipality, there are no identified adverse impacts to land use, transportation, geology and soil, air quality, visual or scenic resources, or socioeconomics associated with any of the alternatives.

Because there are no adverse impacts to any connected surface waters, the only potential for adverse ecological impacts is from continued potential wildlife exposure to contaminated waters in the evaporation and collection ponds. Under the no action alternative, this potential for exposure and adverse impacts is limited to the time it would take for the ponds to be decommissioned and reclaimed upon cessation of groundwater pumping and treatment (approximately two years). Under Alternatives 2 and 3, these ponds would remain in operation for 24 and 10 additional years, respectively, during which time the potential this potential for exposure and adverse impacts would continue.

EPA defines Environmental justice as "*...the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies*" (https://www.epa.gov/environmentaljustice). The Grants Reclamation Project has been present in this area in 1958, before the bulk of residential development to the area occurred. The licensing actions for this project have been implemented in compliance with the NRC requirements under 10 CFR 51 for the National Environmental Policy Act (NEPA). Through the NEPA process, the public have been given equal opportunity to participate and comment on all previous licensing actions that have preceded the proposed action. There are no data to indicate that the proposed action or the alternatives would unfairly impact a specific population based on race, color, national origin, or income. Therefore, no potential adverse impacts related to environmental justice are identified.

There are no short-term adverse public or occupational health impacts associated with the proposed action or the alternatives as there are no current exposure pathways to the affected groundwater. For Alternative 1, the lack of institutional controls and potential for future access to affected groundwater as a domestic drinking water supply over the intermediate to long-term may not afford a reasonable assurance of protection from beneficial use of the groundwater. For Alternatives 2 and 3, the time period over which plume migration is managed and mitigated is significantly increased. Therefore, Alternatives 2 and 3 are deemed to provide a reasonable assurance of protection of public health, safety and the environment over the short to intermediate term (less than 50 years).

The primary point of impacts comparison for the alternatives is with the groundwater resources. Alternative 1 does not afford additional reductions in contaminant volume, mass, mobility or toxicity. On the other hand, Alternative 1 does not continue the irretrievable consumption groundwater through evaporation. As outlined in the description of the proposed alternative (Section 2.1.2), the total volume pumped annually is from 1,380 to 1,950 gpm from affected areas and 300 gpm from the San Andres Formation and Glorietta Formation aquifer for total of 2,250 gpm while 1,400 to 1,900 gpm will be re-injected. The difference between pumped and injected is managed in the evaporation ponds.

On the low end of this range, extracted water is 1,380 gpm affected water + 300 gpm San Andres Limestone and Glorieta Sandstone aquifer water = 1,680 gpm while injected water is 1,400 gpm, the differential being 280 gpm as non-compliant effluent to be evaporated in the lined ponds. On the high end of this range, extracted water is 1,950 gpm affected water + 300 gpm San Andres Limestone and Glorieta Sandstone aquifer water = 2,250 gpm while injected water is 1,900 gpm, the differential being 350 gpm. The lower end range water consumption is roughly 20 percent of pumped affected groundwater (280 gpm/1,380 gpm

= 0.20) while the higher end range water consumption is roughly 18 percent (350 gpm/1,950 gpm = 0.18). Therefore, the range of irretrievable groundwater consumption for the 10 years of proposed operation under Alternative 3 equates to:

- 350 gpm x 60 minutes/hour x 24 hours/day x 365 days/year x 10 years = 1,839,600,000 gallons
- 2800 gpm x 60 minutes/hour x 24 hours/day x 365 days/year x 10 years = 1,471,680,000 gallons

The irretrievable commitment of 1.4 billion to 1.8 billion gallons of groundwater removed from the aquifers affords short term to intermediate term restoration of access to and beneficial use of groundwater as a drinking water supply in an area that has an alternative water supply in place.

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TABLES

Table 1-1 Grants Reclamation Project Groundwater Protection Standards

Constituents	Alluvial Aquifer	Chinle Mixing Zone	Upper Chinle Mixing Zone	Middle Chinle Non-Mixing Zone	Lower Chinle Non-Mixing Zone
Selenium (mg/L)	0.32	0.14	0.06	0.07	0.32
Uranium (mg/L)	0.16	0.18	0.09	0.07	0.03
Molybdenum (mg/L)	0.1	0.1	0.1	0.1	0.1
Sulfate (mg/L)	1500	1750	914	857	2000
Chloride (mg/L)	250	250	412	250	634
Total Dissolved Solids (mg/L)	2734	3140	2010	1560	4140
Nitrate (mg/L)	12	15	*	*	*
Vanadium (mg/L)	0.02	0.01	0.01	*	*
Thorium-230 (mg/L)	0.3	*	*	*	*
Radium-226 and Radium-228 (mg/L)	5	*	*	*	*

* - groundwater protection standards not necessary for the constituents in the indicated zones

Table 1-2. Environmental Monitoring Excluding Groundwater

Media	Number	Locations	Area	Method	Frequency	Analytical Parameters
Air Particulates	4	HMC-1, HMC-1A, HMC-2, HMC-3	At or near the boundary in sectors that have the highest predicted concentrations of radioactive airborne particulates	Continuous (High Volume)	Weekly fiter change or more frequently as required. Samples composited and analyzed quarterly.	Natural Uranium, Radium-226, Thorium-230
	2	HMC-4 and HMC-5	Site boundary nearest occupied residences	Continuous (High Volume)		
	1	HMC-6	Background	Continuous (High Volume)		
	1	HMC-7	Blank			
Radon Gas	4	HMC-1, HMC-1A, HMC-2, HMC-3	At or near the boundary in sectors that have the highest predicted concentrations of radioactive airborne particulates	Continuous Track-etch	Quarterly	Radon-222
	2	HMC-4 and HMC-5	Site boundary nearest occupied residences			
	1	HMC-6	Upgradient Off-Site			
	1	HMC-7	South Boundary			
	1	HMC-16	Background			
Direct Radiation	4	HMC-1, HMC-1A, HMC-2, HMC-3	At or near the boundary in sectors that have the highest predicted concentrations of radioactive airborne particulates	OSL	Semi-annual	Gamma Exposure Rate
	2	HMC-4 and HMC-5	Site boundary nearest occupied residences			
	1	HMC-6	Background			
	1	HMC-16	Background			

Table 1-3. Groundwater Monitoring at the GRP		
Well	**Parameter List Code**	**Frequency of Monitoring**
Alluvial Background Wells		
P, Q, 921	B, F	Annual
Operational Monitoring		
Collection system wells Injection system wells	Total Volume Total Volume	Monthly Monthly
Reversal wells B, BA, KZ, DZ, SM, SN, S2, S5	Water Level	Weekly
San Andres Wells		
Deep #1R, Deep #2R, 943M, 951R	B, F H	Annual Semiannual
Alluvial Compliance Monitoring Wells		
On-Site Monitoring Wells (Evap. Ponds) DD, DD2, X	B, F plus Mn H	Annual Quarterly
Additonal On-Site Monitoring Wells 1A, 1K, 639, 802, B11, D1, F, FB, GH, GN, L, L5, K9, M3, MX, MB, MQ, NC, S4, SUB3, T2, T19, T23, T41, T54	B, F	Annual
South Off-Site Wells 490, 497, 540, 631, 643#, 644, 864, 869, Q5, R3, SUB2	B, F	Annual
Section 34 Land application wells 555, 556, 557, 844, 845, 846	B, F	Annual
North Off-Site Wells(includes Section 28 Land application wells) 688, 881, 882, 883, 884, 886, 888, 893, 659, H2A, MR, H55, MO	B, F	Annual
Western Portion of North Off-Site Wells (Includes Section 33 Land application wells) 541, 551, 647, 649, 654, 899, 996	B, F	Annual
Chinle Compliance Monitoring Wells		
Upper Chinle Wells 494, CE2, CE8, CE9, CE15, CF4, CW3, CW13#, CW18, CW25#	B, F	Annual
Middle Chinle Wells 493, ACW, CW17, CW2, CW28, CW45, CW55, CW62, CW76, R3, Y7	B, F	Annual
Lower Chinle Wells CW29, CW32, CW41, CW42, CW43, V6	B, F	Annual

Note: # Monitoring will start after well ceasing to be used for injection

Table 1-4. Site Analytical Suites

Parameter List Code	Included Parameters (Dissolved)	Method	Reporting Limits	Units
B	Water level			
	pH	A4500-HB	0.01	s.u.
	Total dissolved solids (TDS)	A2540 C	20	mg/L
	Sulfate (SO_4)	E300.0	4	mg/L
	Chloride (Cl)	E300.0	1	mg/L
	Bicarbonate (HCO_3)	A2320 B	5	mg/L
	Carbonate (CO_3)	A2320 B	5	mg/L
	Sodium (Na)	E200.7	0.9	mg/L
	Calcium (Ca)	E200.7	0.5	mg/L
	Magnesium (Mg)	E200.7	0.5	mg/L
	Potassium (K)	E200.7	0.5	mg/L
	Nitrate (NO_3)	E353.2	0.1	mg/L
	Uranium (U)	E200.8	0.0003	mg/L
	Selenium (Se)	E200.8	0.005	mg/L
	Molybdenum (Mo)	E200.8	0.03	mg/L
	Radium-226 (Ra-226)	E903.0	Precision Variable	pCi/L
F	Vanadium (V)	E200.8	0.01	mg/L
	Radium-228 (Ra-228)	RA-05	Precision Variable	pCi/L
	Thorium-230 (Th-230)	E908.0	Precision Variable	pCi/L
H	Water Level			
	TDS	A2540 C	20	mg/L
	SO_4	E300.0	4	mg/L
	U	E200.8	0.0003	mg/L
	Se	E200.8	0.005	mg/L
	Mo	E200.8	0.03	mg/L
	Cl	E300.0	1	mg/L

Table 2-1. Groundwater Flow Model Simulated Predictive Collection and Injection Summary for North Off-Site and South Off-Site Areas

Collection/ Injection Round	Predictive Simulation Years	GRP Area	Simulated Collection (-) Rate (gpm)	Simulated Collection (+) Rate (gpm)
1	1 and 2	North Off-Site	-500	450
		South Off-Site	-550	450
2	3 and 4	North Off-Site	-510	440
		South Off-Site	-540	455
3	5 and 6	North Off-Site	-500	450
		South Off-Site	-550	470
4	7 and 8	North Off-Site	-275	200
		South Off-Site	-554	508
5	9 and 10	North Off-Site	0	0
		South Off-Site	-478	447
6	11 and 12	North Off-Site	0	0
		South Off-Site	-225	231

Table 2-2. Groundwater Flow Model Simulated Predictive Collection and Injection Summary for On-Site Area

Collection/ Injection Round	Predictive Simulation Years	GRP Area	Simulated Collection (-) Rate (gpm)	Simulated Collection (+) Rate (gpm)
1	1 through 4	On-Site	-900	967.5
2	5 through 8	On-Site	-900	972.5
3	9 through 12	On-Site	-900	947.5
4	13 through 16	On-Site	-900	972
5	17 through 20	On-Site	-850	905
6	21 through 24	On-Site	-870	913

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
Seepage to Groundwater from LTP	Natural Attenuation	Natural attenuation	Monitored natural attenuation	The water seepage rate from the LTP and mass discharge to alluvial groundwater will attenuate with time.	**Low**. The time for mass discharge to attenuate is long and causes groundwater under the LTP to exceed standards for a long time.	**Moderate to High**. Routine monitoring would be required to evaluate mass discharge and impact to groundwater.	**Low**. Long attenuation timeframe will require extended monitoring and reporting duration.	**Yes**. Monitored natural attenuation of mass discharge from the LTP is expected be a component in each alternative.
	Removal	Excavation	Excavation and disposal	Excavate soil, sludge, and pore water from LTP to be disposed in a properly lined surface impoundment constructed off-site.	**High**. Would eliminate mass discharge to groundwater but would take many years to implement. Increase in truck and heavy equipment traffic could adversely affect community.	**Low**. Technically challenging to safely implement because of very large size/volume. Complex permitting and siting process. Uncertain availability of land and resources to implement.	**High**. Relatively high engineering design and capital costs to construct new impoundment, excavate LTP, and safely transport waste.	**No**. Not feasible because of stress on local resources, increase in human health risks from transporting waste, permitting and siting complexity/uncertainty, and costs.
		Extraction	Extraction wells	Pump recoverable pore water collected in vertical extraction wells installed throughout the vertical extent of the LTP. Collection rate can be increased using vacuum-enhanced extraction.	**Moderate**. Removal of recoverable pore water decreases the mass discharge to groundwater. Heterogeneity of LTP matrix can limit ability to effectively collect recoverable pore water with extraction wells.	**High**. Readily implementable with existing extraction well network and ex situ water treatment systems.	**Low to Moderate**. Limited to no capital costs because of existing systems. Moderate O&M costs likely for long time along with a decrease in cost effectiveness with time.	**No**. Since implementation in 1995, recovered water volume decreased with time. Currently, water collection in extraction wells is not sufficient to operate pumps.
			Toe Drains	Collect mobile pore water that drains by gravity to the side slopes of the LTP in toe drains installed along the perimeter of the LTP.	**Low to Moderate**. Decreases mass discharge to groundwater, but only removes a portion of recoverable pore water (near the side slopes) draining to groundwater.	**High**. Readily implementable with existing toe drain system and ex situ water treatment systems.	**Low**. No capital costs because of existing systems. Low O&M costs likely for long time.	**Yes**. Currently installed to limit seepage of mobile water near LTP side slopes to alluvial groundwater.
			Horizontal collection wells	Recoverable pore water collects in horizontal wells and drains by gravity to collection sumps.	**Low to Moderate**. May decrease mass discharge to groundwater, but collection by gravity is expected to be limited and would require a dense well network.	**Low**. Ability to install horizontal wells through base of LTP is unknown. The large number of horizontal wells required to significantly capture seepage limits implementability.	**High**. High capital costs to install many wells needed to provide adequate capture beneath area of the LTP and to decrease mass discharge to groundwater.	**No**. Uncertain effectiveness, low implementability, and high costs make this less feasible compared to other extraction options.
	Containment	Physical barrier	Engineered cover	Mitigate infiltration of precipitation into the LTP through construction of an engineered cover.	**Moderate to High**. Decreases long term seepage from the LTP by limiting infiltration from precipitation. Seepage and mass discharge of the stored mobile pore water would continue after cover installation.	**High**. Readily implementable. Construction of the final cover is specified in the Decommissioning and Reclamation Plan.	**High**. Capital costs are expected to be high for a final cover.	**Yes**. Required as part of the Decommissioning and Reclamation Plan. The final engineered cover is currently installed on the out slopes of the LPT.
			Slurry wall	Install physical grout or slurry wall around the footprint of the LTP to contain groundwater impacted by seepage from the LTP.	**Low**. Mass discharge from seepage is not affected. Impact to alluvial groundwater would be contained but migration of COCs to Upper Chinle could continue.	**Low**. Technically difficult to implement because of depth to bottom of alluvial aquifer. Length and size of wall makes implementation difficult.	**High**. The large size and scale of a slurry wall makes the capital costs relatively high.	**No**. Significantly less feasible than an engineered cover.

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
Seepage to Groundwater from LTP	Treatment	Physical/Chemical	Water flushing	Inject water using injection wells to dilute and displace pore water containing dissolved contaminants. Mobile pore water is displaced and collected by LTP extraction wells, toe drains, or seeps to the alluvial aquifer.	**Low to Moderate**. Enhances removal of COC mass from the LTP and may increase mass discharge to groundwater during operation to provide long-term reduction in mass discharge. Soil heterogeneity can limit effectiveness. Implementation (2002 to 2015) decreased concentrations and was stopped because of limited benefit from continued operation.	**Moderate to High**. Readily implementable with existing wells and infrastructure. Expected to increase rate of recovered pore water that requires ex situ treatment.	**Low**. No capital costs because of existing infrastructure in LTP.	**No**. Implemented from 2002 to 2015 to decrease mass of dissolved COCs in the LTP pore water. An evaluation showed continued operation beyond 2015 provided limited benefit.
			Tripolyphosphate	Tripolyphosphate (TPP) solution is injected into the LTP. Uranium is removed from LTP pore water and immobilized by precipitation as phosphate minerals (primarily autunite) and adsorption to precipitated phosphate minerals (primarily hydroxyapatite). Requires addition of calcium to exceed calcium-phosphate saturation limits. Hydroxyapatite provides long-term immobilization of uranium in LTP pore water, which can decrease mass discharge to groundwater.	**Low to Moderate**. Field-scale study in the LTP indicated that immobilization of uranium required pore water pH to be conditioned (<7.0) with sulfuric acid solution injection. LTP permeability heterogeneity, adsorption of phosphate onto tailings solids, and the variability in the buffering capacity of the LTP affected the ability to deliver the injected solutions and maintain optimal geochemical conditions.	**Moderate**. Injection of solutions via direct push and wells is readily implementable. Large volume of LTP and required solutions makes full-scale implementation difficult. Solutions and injection pressures can be hazardous to operators.	**Moderate**. Costs primarily associated with large number of injection points/wells and large volume of chemical solutions. Extensive monitoring would be required to track and evaluate performance.	**No**. The complex geochemical and heterogeneous soil conditions within the LTP are expected to limit the performance of TPP and are expected to severely limit the feasibility of applying TPP full-scale within the LTP.
Groundwater Plume	Natural Attenuation	Monitored natural attenuation	Monitored natural attenuation	Concentrations of COCs in groundwater naturally attenuate by geochemical transformation, adsorption, and dilution with time to achieve site standards.	**Low**. Although natural attenuation decreases COC concentrations, the time to achieve site standards is expected to be very long.	**Moderate to High**. Routine monitoring would be required to evaluate natural attenuation with existing monitoring network.	**Low**. Long attenuation timeframe will require extended monitoring and reporting duration.	**Yes**. Monitored natural attenuation of groundwater is expected be a component of each alternative.
	Institutional Controls, Engineering Controls	Land use controls, access restrictions	Land use zoning, deed restrictions, fencing, warning signs	Restrictions would prevent use of groundwater. Fences limit access. Signs warn of exposure to contaminants.	**Moderate**. Relies on administrative and engineering measures to limit exposure to groundwater COCs. ICs effective in short term but must be maintained and enforced to provide long-term protection.	**Moderate to High**. Readily implemented using existing guidance. May require offsite land-owner concurrence and compliance. Some uncertainty on enforcement and reliability of long-term administration.	**Low**. Cost associated with long-term administration.	**Yes**. Included in each alternative until human health standards are achieved.
	Removal	Extraction	Groundwater extraction wells	Remove contaminated groundwater with extraction wells.	**Moderate to High**. Effectively removes COCs and contaminated groundwater. Aquifer heterogeneity and matrix back-diffusion limits the ability to achieve groundwater standards.	**Moderate to High**. Readily implemented using existing well network. Aquifer heterogeneity can limit extraction rates requiring more wells to achieve standards.	**Low to Moderate**. Minimal capital costs using existing infrastructure. Long-term O&M costs for infrastructure and ex situ treatment and disposal of extracted groundwater.	**Yes**. Extraction wells are currently removing contaminated groundwater from aquifers.

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
Groundwater Plume	Removal	Extraction	Groundwater extraction trenches	Groundwater would collect in interceptor trenches and be removed.	**Low**. Capture of contaminated groundwater is severely limited because aquifer depths are greater than practical depths for trenches.	**Low**. Impractical to install trenches to full depth of alluvial aquifer to remove impacted groundwater. Cannot access deeper aquifers.	**High**. High capital costs to install deep trenches. Long-term O&M costs for infrastructure and ex situ treatment and disposal of extracted groundwater.	**No**. Not feasible because depths of aquifers exceed practical application.
		Injection and extraction	Directed groundwater recirculation	Injection of treated or fresh water and extraction of groundwater are configured to control the direction and increase the velocity of groundwater flow that enhances recovery and removal of impacted groundwater.	**Moderate to High**. Effectively enhances removal of COCs mass from groundwater compared to extraction only. Aquifer heterogeneity and matrix back-diffusion limits the ability to achieve groundwater standards.	**Moderate to High**. Readily implemented using existing well network. Aquifer heterogeneity can limit extraction and injection rates needed to maintain plume capture.	**Moderate**. Minimal capital costs using existing wells and infrastructure. Long-term O&M costs for infrastructure and ex situ treatment of extracted groundwater. Greater ex situ treatment may be required for injected water.	**Yes**. Extraction and injection wells are currently removing dissolved COC mass and hydraulically containing groundwater plumes at the Site.
	Containment	Hydraulic barriers	Groundwater extraction wells	Groundwater would be extracted to create hydraulic capture zones and prevent migration of groundwater plumes.	**Moderate to High**. Effective at capturing dissolved plumes and preventing continued migration. Aquifer heterogeneity and matrix diffusion decreases ability to achieve groundwater standards.	**Moderate to High.** Readily implemented using existing well network. Aquifer heterogeneity can limit extraction rates requiring more wells to maintain control.	**Low to Moderate**. Minimal capital costs using existing infrastructure. Long-term O&M costs for infrastructure and ex situ treatment and disposal of extracted groundwater.	**Yes**. Extraction wells are currently containing groundwater plumes at the Site.
			Groundwater extraction trenches	Groundwater would collect in interceptor trenches to create hydraulic control and prevent migration of groundwater plumes.	**Low**. Capture and control of plumes is severely limited because aquifer depths are greater than practical depths for trenches.	**Low**. Impractical to install trenches to full depth of alluvial aquifer to remove impacted groundwater. Cannot access deeper aquifers.	**High**. High capital costs to install deep trenches. Long-term O&M costs for infrastructure and ex situ treatment and disposal of extracted groundwater.	**No**. Not feasible because depths of aquifers exceed practical application.
			Injection wells	Injection of clean water into the aquifer increases hydraulic head to create hydraulic barriers that control groundwater flow directions and prevent plume migration.	**Moderate**. Effective at containing dissolved plumes and preventing continued migration. Does not remove COCs mass.	**Moderate to High**. Readily implemented using existing well network. Aquifer heterogeneity can limit injection rates requiring more wells to maintain control.	**Moderate**. Minimal capital costs using existing infrastructure. Long-term O&M costs for ex situ treatment are relatively higher to treat groundwater to standards so that it can be injected.	**Yes**. Injection wells are currently being used to create hydraulic barriers that limit and control migration of groundwater plumes at the Site.
			Injection trenches (subsurface injection lines)	Injection and infiltration of clean water into the aquifer increases hydraulic head to create hydraulic barriers that control groundwater flow directions and prevent plume migration.	**Low to Moderate**. Vertical variability in lithology (e.g. clay lenses) can affect injection rates and location of increased hydraulic head; thus, limiting effectiveness. Does not remove COCs mass.	**Moderate to High**. Readily implemented using existing well network.	**Moderate**. Minimal capital costs using existing infrastructure. Long-term O&M costs for ex situ treatment are relatively higher to treat groundwater that can be injected.	**Yes**. Injection lines are currently being used to create hydraulic barriers that limit migration of groundwater plumes at the Site.

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
Groundwater Plume	Treatment	In situ	Bioremediation	A readily degradable organic carbon substrate is injected to create an anaerobic in situ reactive treatment zone. The anaerobic conditions reduce the oxidation states of uranium, molybdenum, and selenium, which are removed from groundwater through creation of low solubility metal/nonmetal precipitates.	**Low**. A field-scale pilot study showed incomplete treatment in the study area and highlighted the complexity of uniformly delivering an organic carbon substrate and nutrients to maintain the appropriate in situ redox conditions that are required for the geochemical reactions.	**Moderate**. Requires extensive injection network to deliver substrate solution. Aquifer heterogeneity may decrease ability to uniformly deliver substrate solution. Appropriate organic substrates are readily available.	**Moderate to High**. Capital costs for new injection wells to complement existing wells to establish a treatment zone. Continual or periodic injection events required to maintain required geochemical conditions.	**No**. Difficult to implement for large treatment areas and requires long-term delivery of substrates. Long-term stability of precipitates uncertain if geochemical conditions change.
			Hydroxyapatite	Two solutions (sodium phosphate and calcium citrate) are injected to create an in situ permeable reactive barrier (PRB). Microbes degrade the citrate to release calcium, which reacts with phosphate to form hydroxyapatite precipitate. Hydroxyapatite adsorbs or sequesters COCs from groundwater flowing through the PRB.	**Moderate to High**. Bench and field testing at other sites show that hydroxyapatite can decrease groundwater concentrations of COCs to less than standards. A treatability study is recommended to evaluate Site-specific effectiveness and feasibility.	**Moderate**. Requires extensive injection network to deliver treatment solutions. Aquifer heterogeneity may decrease ability to uniformly deliver solutions and establish PRB. Required chemical solutions are readily available.	**Moderate**. Capital costs for new injection wells to complement existing wells to establish PRB. Minimal O&M costs after PRB created.	**Yes**. Long-term favorable performance at other sites indicates a hydroxyapatite PRB may be a feasible in situ remedy for the Site. A Site-specific treatability study is recommended.
			Tripolyphosphate	TPP solution is injected to create an in situ PRB. Uranium is removed from groundwater and immobilized by chemical precipitation as phosphate minerals and adsorption to precipitated phosphate minerals (hydroxyapatite). Requires addition of calcium to exceed calcium-phosphate saturation limits. Formation of hydroxyapatite adsorbs or sequesters COCs from groundwater flowing through the PRB.	**Moderate to High**. A field-scale treatability study indicated that sustained immobilization of uranium was occurring in the vicinity of the injection wells. During study, the distribution of tripolyphosphate and the extent of the PRB and treatment effectiveness were affected by aquifer heterogeneity and variable groundwater flow.	**Moderate**. Requires extensive injection network to deliver treatment solutions. Aquifer heterogeneity may decrease ability to uniformly deliver solutions and establish PRB. Required chemical solutions are readily available.	**Moderate**. Capital costs for new injection wells to complement existing wells to establish PRB. Minimal O&M costs after PRB created.	**No**. Not retained in favor of a hydroxyapatite PRB, which is expected to provide longer effective treatment of groundwater.

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
		Ex situ (requires groundwater extraction)	Reverse Osmosis	Reverse osmosis (RO) is a common water treatment technology that uses a partially permeable membrane to remove ions from water. Untreated water is applied at pressure to exceed osmotic pressure. RO also produces a concentrated ion waste solution or brine.	**High**. An existing RO treatment facility at the Site is effectively treating recovered groundwater with high TDS and relatively higher COC concentrations. Additional treatment steps and polishing may be required to achieve standards for injection of water.	**High**. The existing RO treatment facility has a maximum treatment capacity of 1,200 gpm and an expected annual average capacity of 800 gpm. Pretreatment with lime clarification and sand filtration are required to decrease suspended and dissolved solids. Creates concentrated brine waste needing disposal.	**Moderate**. No capital cost for existing treatment system. Moderate O&M costs to operate pretreatment and RO treatment systems.	**Yes**. The existing RO system is retained as the primary treatment option for groundwater with relatively higher COCs concentrations recovered from the LTP and the alluvial aquifer.
Groundwater Plume	Treatment	Ex situ (requires groundwater extraction)	Zeolite	Zeolite, specifically clinoptilolite, is a microporous, negatively charged aluminosilicate mineral that adsorbs and removes cations from water. For treatment of groundwater, pH adjustment is used to change the oxidation state of uranium and remove from water with zeolite. The adsorption capacity of zeolite is regenerated with an acid solution.	**Moderate to High**. An existing zeolite treatment facility at the Site is effectively treating recovered groundwater with relatively low uranium concentrations collected from offsite. Less effective for other COCs and high uranium concentrations.	**High**. The existing zeolite treatment facility has a maximum treatment capacity of 1,500 gpm and an expected annual average capacity of 1,050 gpm.	**Low to Moderate**. No capital cost for existing treatment system. Low to moderate costs to operate and maintain treatment beds.	**Yes**. The existing zeolite system is retained as the primary treatment option for groundwater with relatively low uranium concentrations that is recovered from the offsite plume.
			Ion exchange	Ion exchange (IX) is a common water treatment process where ion-specific resins remove ions from the water. Ion exchange resins can be regenerated with salt solutions (e.g. sodium chloride) that displace the targeted ions (e.g. uranium and molybdenum).	**Moderate to High**. Site-specific bench testing indicated successful treatment of uranium and molybdenum using ion-specific resins with high sorption capacity when treating high-quality effluent from RO. An IX resin was the final polishing step to remove uranium, molybdenum, and selenium from the electrocoagulation pilot study.	**High**. IX systems are typically available as packaged units with treatment resins for the Site COCs. An existing IX system at the Site not currently being used could be readily modified for use as a polishing step.	**Low**. Minimal capital cost to modify the existing system for use as a polishing step if needed. Low operation costs.	**Yes**. Retained as a polishing step following reduction in total dissolved solids (<100 mg/L following RO treatment) if higher quality effluent is needed.

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
			Electrocoagulation	Electrocoagulation (EC) is a water treatment method that applies an electrical current through a treatment vessel via an anode and cathode. As the anode is corroded, metal hydroxide flocculants are formed that adsorb metals from the water. The flocculants aggregate and settle for removal. Additional treatment processes may be required to remove suspended solids/flocculants and meet treatment goals.	**Moderate to High**. A pilot scale study with multiple treatment steps was completed at the site using an iron anode to provide iron hydroxide flocculent. Uranium treatment goal achieved, but molybdenum treatment would require separate removal steps to achieve goal.	**Low to Moderate**. Multiple treatment steps were required and included aeration (redox optimization), EC, pH adjustment (pH<4), passive separation (i.e. settling tank), ultrafiltration, and ion exchange.	**High**. High capital cost for new equipment that includes several pre- and post-treatment steps. High costs for electricity, materials, and maintenance of multiple treatment steps.	**No**. Other effective and less costly treatment options are available.
			Activated alumina	Activated Alumina (AA) is a highly porous aluminum oxide solid with a very high surface area to weight ratio that is used in treatment vessels to remove dissolved ions from water similar to the ion exchange treatment process. Spent AA is typically regenerated with a caustic solution (1% NaOH) to remove the adsorbed ions.	**Moderate to High**. Bench testing indicated successful treatment of uranium and molybdenum.	**Moderate to High**. Typically available as packaged units that could be readily implemented as a polishing step. Requires pretreatment to decrease total dissolved solids.	**Moderate**. Moderate capital cost for new equipment. Moderate operation costs.	**No**. Bench testing indicated adsorption capacity was significantly less than ion exchange resins.
Groundwater Plume	Treatment	Disposal	Evaporation	Untreated water and the brine waste from RO are disposed in lined evaporation ponds where passive and forced (spray) evaporation removes water. Precipitated solids from evaporation accumulate in the ponds.	**High**. Evaporation ponds have been used at the Site since 1986 to dispose and store treated and untreated water. Seasonal changes to evaporation rates can change and sometimes limit sitewide groundwater removal and treatment rates.	**High**. Multiple evaporation ponds are being used at the Site. Rehabilitation of existing ponds and construction of new ponds has been evaluated at the Site.	**Moderate to High**. Operation costs are low. High capital costs would be required to construct a new pond if needed.	**Yes**. Evaporation is the current disposal process option.
			Land application	Untreated or treated water is disposed by application to land or through irrigation of crops.	**High**. Alluvial groundwater that met site-specific irrigation standards was applied using flood and center-pivot systems to crops. Seasonal crop growth would control and could limit application rates.	**Low to Moderate**. Readily implemented with standard equipment. Although monitoring indicated that uranium and selenium were retained in soil and crops with no significant health concerns, uranium migration in soil was deeper than predicted. Groundwater modeling indicated some groundwater impacts could occur.	**Low**. Capital and operation costs are low.	**No**. Not retained because of observed migration and accumulation of uranium in soil and the potential for limited impact to groundwater under the application area. The previous land application program was stopped at the request of regulatory agencies.

Table 2-3. Identification and Screening of Technologies and Process Options

Media	General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Costs	Retained (Yes/No) and Screening Comments
			Deep well injection	Untreated or treated water is disposed by injection through a deep well into formations with poor water quality that are typically below and isolated from drinking water aquifers.	**High**. Deep aquifers with potentially high injection capacity were identified.	**Low**. Not readily implementable because of permitting concerns and monitoring requirements. Untreated water quality (TDS) may be poorer than water quality of the deep aquifer and would require further evaluation and monitoring of water quality at depths 2,100 feet below the Site.	**High**. High capital costs to install deep injection well(s) and required monitoring wells. Additional investigation costs would be required to evaluate feasibility.	**No**. Not retained because of permitting concerns and uncertainty of deep groundwater quality that would determine implementability.

Table 2-4. Technologies and Process Options Retained

Media	General Response Action	Remedial Technology Type	Process Option
Seepage to Groundwater from LTP	Natural Attenuation	Monitored natural attenuation	Monitored natural attenuation
	Removal	Extraction	Toe drains
	Containment	Physical barrier	Engineered cover
Groundwater Plume	Natural Attenuation	Monitored natural attenuation	Monitored natural attenuation
	Institutional Controls, Engineering Controls	Land use controls, access restrictions	Land use zoning, deed restrictions, fencing, warning signs
	Removal	Extraction	Groundwater extraction wells
		Injection and extraction	Directed groundwater recirculation
	Containment	Hydraulic barriers	Groundwater extraction wells
			Injection wells
			Injection trenches (lines)
	Treatment	In Situ	Hydroxyapatite
		Ex situ (requires groundwater extraction)	Reverse Osmosis
			Zeolite
			Ion exchange
		Disposal	Evaporation

Table 3-1 Land Occupancy in Subdivisions near GRP

Subdivision	Number of Lots	Vacant	Percent Occupied
Broadview Acres	56	17	70%
Felice Acres	22	7	68%
Murray Acres	30	10	67%
Pleasant Valley Acres	36	14	61%
Valle Verde	109	83	24%

Table 3-2. Plant Species of Interest

Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Flowering Period	Likelihood of Occurrence
Cinder Phacelia	*Phacelia serrata*		NM rare	Primarily in deep volcanic cinders associated with volcanic cones, but also roadcuts and abandoned quarries in open, exposed, sunny locations; near ponderosa pine and piñon-juniper woodlands; 1,800-2,200 m (5,900-7,200 ft).	Flowers July to October, primarily late August and early September.	**Low** - More typical of coarse, rocky, highly well drained substrates; though limited potential may occur in areas of roadcuts, presence is unlikely in survey parcels.
Laguna Fame Flower	*Talinum brachypodum*		NM rare	Very shallow pockets of calcareous silt to clay soils overlying limestone or travertine, or fine silty sand overlying calcareous sandstones; open piñon-juniper woodland with little understory and scattered cacti and shrubs or Chihuahuan desert scrub. Preference for substrates of fine-grained non-calcareous iron rich red sandstone of the "Rimrock Country" of the Colorado Plateau.	Flowers June to August.	**Low** - Iron rich red sandstone typical of habitat areas not present, and vegetation associations are lacking (Chihauhuan desert scrub and cacti areas lacking).
New Mexico Sunflower	*Helianthus praetermissus*		NM rare	This species is known only from the type specimen collected in 1851. The locality was the head of the Rio Laguna (now Rio San Jose) at Ojo de la Gallina, on the north side of the Zuni Mountains. This species may have been named from a depauperate specimen of Helianthus paradoxus. Based on limited information, habitats may include perhaps wet ground.	Flowers in September.	**Low** - Species has not been observed since 1851.
Parish's Alkali Grass	*Puccinellia parishii*		E	Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes at 800-2,200 m (2,600-7,200 ft) range-wide. The species requires continuously damp soils during its late winter to spring growing period. It frequently grows with Distichlis stricta (salt grass), Sporobolus airoides (alkali sacaton), Carex spp. (sedges), Scirpus spp. (bulrushes), Juncus spp. (rushes), Eleocharis spp. (spike rushes), and Anemopsis californica (yerba mansa).	Flowers May to June.	**Low to Medium** -Localized areas of wetted soils occur where piping and pumping persists and contain similar plant associations.
Pecos Sunflower (Puzzle Sunflower)	*Helianthus paradoxus*	T	E	Saturated saline soils of desert wetlands. Usually associated with desert springs (cienegas) or the wetlands created from modifying desert springs; 1,000-2,000 m (3,300-6,600 ft). Helianthus paradoxus is a true wetland species that requires saturated soils; adult plants still grow well when inundated	Flowers August to October.	**Low to Medium** - Localized areas of wetted soils occur where piping and pumping persists; however, likelihood of occurrence even in these areas is extremely low due to dominance of thick cattails.

Table 3-2. Plant Species of Interest

Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Flowering Period	Likelihood of Occurrence
Todilto Stickleaf	*Mentzelia todiltoensis*		NM rare	Outcrops of gypsum in the Todilto Formation; 1,700-1,910 m (5,600-5,840 ft).	Flowers open in the evening hours, late June through September.	**Low** - No gypsum outcrops occur in the study area.
Yeso Twinpod	*Physaria newberryi var. yesicola*		NM rare	The habitat is nearly barren badlands and canyon sides of various slopes and exposures between the elevations of 1700 and 2100 m. It occurs on sandy gypsum and other silty strata in short grass steppe and juniper savanna; in the Permian age Yeso Formation. The Yeso formation is comprised of a soft, silty sandstone interbedded with gypsum, limestone, shale and siltstone strata of various thickness.	Flowers April and May.	**Low** - May occur in shortgrass steppe, however Yeso formation not known to occur underlying area. Other ecological information indicates this species occurs in barren badlands and canyon sides.
Zuni Fleabane (Acoma Fleabane)	*Erigeron acomanus*	T	E	Steep, sandy slopes and benches beneath sandstone cliffs of the Entrada Sandstone Formation in piñon-juniper woodland; 2,100-2,170 m (6,900-7,100 ft). Vegetation cover is usually high; prefers north facing slopes. Typical of high selenium soils.	Flowers in July.	**Low -** No suitable habitat in survey areas.
Zuni Milkvetch	*Astragalus missouriensis var. accumbens*		NM rare	Habitats include gravelly clay banks and knolls, in dry, alkaline soils derived from sandstone, in piñon-juniper woodlands; 1,890-2,410 m (6,200-7,900 ft).	Flowers (March) May through June (August).	**Medium** - May be locally abundant within its limited range. Alkaline soils derived from sandstone occur in study area parcels.

Notes: Queried from NMNHP, http://nmrareplants.unm.edu/rarelist.php, January 2018, and USFWS IPAC for Cibola County, https://ecos.fws.gov/ipac/, January 2018.

T = threatened; E = endangered; NM = New Mexico

Source: Lone Mountain, 2018

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bat	Big Free-tailed Bat	*Nyctinomops macrotis*		NM sensitive	Seasonal migrant through much of its range. Found in urban areas, dry forests, and pine forests.	**Low** - May forage or pass through on a seasonal basis, but no suitable habitat is present.
Bat	Fringed Myotis	*Myotis thysanodes*		NM sensitive	Found at middle elevations of 1,200-2,150 m in desert, grassland, and woodland habitats. Roosts in caves, mines, rock crevices, buildings, and other protected sites.	**Low** - Study area is outside species elevation range.
Bat	Long-eared Myotis	*Myotis evotis*		NM sensitive	Widespread throughout the western U.S. in a wide range of habitats but most commonly found in coniferous forests. Prefer snags that reach high into or above the forest canopy and roost in crevices of sandstone boulders, stumps of clear-cut stands, abandoned buildings, cracks in the ground, caves, mines, and loose bark on living and dead trees.	**Low** - May forage or pass through on a seasonal basis.
Bat	Long-legged Myotis	*Myotis volans*		NM sensitive	Found in forested regions and roost in trees, rock crevices, fissures in stream banks, and buildings.	**Low** - May forage or pass through, but no suitable habitat in the study area.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bat	Pale Townsend's Big-eared Bat	*Corynorhinus townsendii*		NM sensitive	Occurs in semi-desert shrublands, desert scrub, sagebrush, chaparral, piñon-juniper woodlands, and open montane forests. Roosts mostly in caves or mines; at night may roost in abandoned buildings. Will also use rock crevices and hollow trees as roost sites. In summer, this species occurs widely across the state.	**Medium** - Suitable habitat within study area. Species occurs widely in New Mexico during summer months over desert scrub and other habitats.
Bat	Southwestern Little Brown Myotis	*Myotis occultus*		NM sensitive	Found in a variety of habitats including urban and agricultural areas, riparian habitats, grasslands, and forests. Hibernates in caves and mines, and roosts in buildings in New Mexico. Typically found near lakes or streams as they prefer to forage over water, but will also forage among trees in open areas.	**Low** - May forage over ponds or roost in abandoned structures near study area.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bat	Spotted Bat	*Euderma maculatum*		T	Forages in forest openings, piñon-juniper woodlands, riparian habitats, meadows, and agricultural fields. It is a broad-ranging species; however, its distribution is highly associated with prominent rock features. Rocky cliffs with suitable roosting substrate (e.g., crevices, cracks) are critical to this species. Perennial water sources also are important for this species.	**Low** - No suitable habitat in study area. May be found in forests or rocky cliffs outside study area.
Bat	Western Small-footed Myotis	*Myotis ciliolabrum*		NM sensitive	Common in arid desert, badland, and semiarid habitats. Occurs at low to moderate elevations as high as 9,500 ft in New Mexico. Wide ecological range from rock outcrops in open grasslands to canyons and woodlands. Roosts include cracks and crevices in cliffs, behind tree bark, mines, caves, tunnels, and other man-made structures.	**Medium** - Potential habitat for foraging within study area.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bat	Yuma Myotis	*Myotis yumanensis*		NM sensitive	Found in a variety of habitats from juniper and riparian woodlands to desert regions near open water. Almost guaranteed to find near rivers, streams, ponds, and lakes. Roost in caves, attics, buildings, mines, underneath bridges, and other similar structures.	**Low** - No suitable aquatic habitat present. May roost in abandoned structures near study area.
Bird - MBTA	Bendire's Thrasher	*Toxostoma bendirei*	BCC		Desert species found in various dry, semi-open habitats, particularly areas of tall vegetation, cholla cactus, creosote bush and yucca, and in juniper woodlands.	**Medium -** Potential for breeding and foraging habitat to be present.
Bird - MBTA	Black-chinned Sparrow	*Spizella atrogularis*	BCC		Occupies brushy mountain slopes, open chaparral, and sagebrush habitats. Found mostly in arid scrub on hillsides from low foothills to 7,000 ft elevation.	**Medium -** Potential for breeding and foraging habitat to be present.
Bird - MBTA	Brewer's Sparrow	*Spizella breweri*	BCC		Occurs in the arid intermountain western U.S. Breeds on sagebrush flats and open scrubby areas. Sometimes found in stands of saltbush, on open prairie, or in pinyon-juniper woodland.	**High** - Suitable habitat present and within the common breeding range of the species.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - MBTA	Chestnut-collared Longspur	*Calcarius ornatus*	BCC		Found along the plains and prairies, breeding in shortgrass prairies containing slightly longer grass and scattered taller weeds. Overwinters in shortgrass prairies and fields.	**Medium** - Habitat present for overwintering and migration route.
Bird - MBTA	Grace's Warbler	*Dendroica graciae*	BCC		Occupies pine-oak forests of mountain regions. Breeds in the tops of pine trees, spruce, fir, and oak thickets. Overwinters in pine-oak woodlands in the mountains.	**Low** - Potential to occur in nearby forests, not likely within project area due to lack of suitable habitat in the study area.
Bird - MBTA	Gray Vireo	*Vireo vicinior*	BCC	T	Open woodlands/shrublands, mountain slopes, mesas, open chaparral, scrub oak, and junipers; occurs in New Mexico only in warmer months (April-September). Found in elevations between 3,000 to 6,500 ft.	**Medium** - Habitat present for breeding during spring and summer.
Bird - MBTA	Lesser Yellowlegs	*Tringa flavipes*	BCC		Migrates through New Mexico and found in marshes, mudflats, shores, ponds, and open boreal woods.	**Medium** - Potential to pass through during migration.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - MBTA	Lewis's Woodpecker	*Melanerpes lewis*	BCC		Prefers scattered or logged forests, river groves, burns, and foothills. During the summer requires open country for foraging so is often found in Cottonwood groves, open pine-oak woods, burned or cut-over woods. Overwinters in oak groves and orchards.	**Low -** No suitable habitat present within the study area. Likely present in forests outside the study area so may pass through incidentally.
Bird - MBTA	Loggerhead Shrike	*Lanius ludovicianus*	BCC	NM sensitive	Found in semi-open country with lookout posts, wires, trees, and scrub. Breeds in semi-open terrain from large clearings in wooded regions to open grasslands or desert with a few scattered trees or large shrubs.	**High/Confirmed** - Species observed and identified within the study area.
Bird - MBTA	Long-billed Curlew	*Numenius americanus*	BCC		Migrates through New Mexico and breeds only in the northeastern corner of New Mexico. Found on the high plains, and breeds in native dry grassland and sagebrush prairie.	**Medium** - Potential to pass through during migration.
Bird - MBTA	Marbled Godwit	*Limosa fedoa*	BCC		Migrates through New Mexico. Found in prairies, pools, shores, and tideflats. Breeds in the northern Great Plains in native prairies containing marshes or ponds.	**Low -** Potential for species to occur within the study area during migration.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - MBTA	Mountain Plover	*Charadrius montanus*		NM sensitive	This species is a native of the short-grass prairie. Breeds on open plains at moderate elevations and overwinters in short-grass plains and fields, plowed fields, and sandy deserts.	**Medium** - Suitable habitat present for breeding and overwintering.
Bird - MBTA	Olive-sided Flycatcher	*Contopus cooperi*	BCC		Occupies coniferous forests, burns, and clearings. Breeds in coniferous forests in the mountains, particularly around the edges of open areas including bogs, ponds, and clearings.	**None** - No suitable habitat within the study area. Only suitable habitat is in the nearby forests.
Bird - MBTA	Pinyon Jay	*Gymnorhinus cyanocephalus*	BCC		Found in New Mexico year-round in pinyon pines and junipers. Seldom found outside of pinyon pines in pinyon-juniper woods, but may be seen in streamside groves, oak woods, or other habitats if the pinyon cone crop fails.	**None** - No suitable habitat within the study area. Only suitable habitat is in the forests outside the study area.
Bird - MBTA	Rufous Hummingbird	*Selasphorus rufus*	BCC		Migrates through New Mexico. Found along forest edges, streamsides, and mountain meadows. Occur at all elevations but more common in lowlands during spring, and mountain meadows during late summer and fall.	**Medium** - Potential to pass through during migration.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - MBTA	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	E	E	Riparian habitat consisting primarily of native trees such as willow; nest in shrubs and small trees in willow thickets, shrubby mountain meadows and deciduous woodlands along streams. Habitat patches must be at least 0.25 acres in size and at least 30 ft wide (USFWS 2014).	**Low** - No suitable riparian habitat is present for nesting or foraging. However, species known to use habitat patches so area containing willows should be assessed.
Bird - MBTA	Virginia's Warbler	*Vermivora virginiae*	BCC		Occupies oak canyons, brushy slopes, and pinyons. Breeds in New Mexico in dry mountainsides in scrub oak, chaparral, pinyon-juniper woods, or other low brushy habitats.	**Medium** - Suitable habitat present and project area within common breeding range for species.
Bird - MBTA	Yellow-billed Cuckoo (western pop)	*Coccyzus americanus occidentalis*	T	T	Mature riparian habitats most commonly associated with cottonwood or other native forests; associated with lowland deciduous woodlands, willow and alder thickets, second-growth woods, deserted farmlands and orchards.	**None** - No suitable riparian habitat is present within the study area.
Bird - Raptor	Arctic Peregrine Falcon	*Falco peregrinus tundrius*		T	Hunting habitats include croplands, meadows, riverbottoms, marshes and lakes; breeds in the Arctic tundra.	**Low** - Hunting habitat may be present during migration.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - Raptor	Bald Eagle	*Haliaeetus leucocephalus*		T	Forested areas along coasts, large lakes, and rivers. Year-round occurrence	**Low** - May hunt or pass through incidentally, but study area does not contain suitable aquatic habitat preferred by species.
Bird - Raptor	Burrowing Owl	*Athene cunicularia*	BCC		Found in open grasslands, prairies, farmland, deserts, steppe environments, and airfields. Favors areas of flat, open ground with very short grass or bare soil. Most often associated with high densities of burrowing mammals, such as prairie dogs, but also airports, golf courses, vacant lots, industrial parks, and other open areas when prairie dog colonies are not present.	**High** - Suitable habitat present in prairie dog colonies within the study area.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - Raptor	Golden Eagle	*Aquila chrysaetos*	BCC		Found in open mountains, foothills, plains, and open country. Require open terrain for hunting. Avoid developed areas and primarily found in the mountains up to 12,000 ft, canyonlands, rimrock terrain, and riverside cliffs and bluffs. Nest on cliffs and steep escarpments near open grasslands, chaparral, shrubland, and forests.	**High/Confirmed** - Suitable hunting habitat present within the study area, and nesting habitat present along cliffs outside of the study area. Incidental observations of this species have were noted previously.
Bird - Raptor	Long-eared Owl	*Asio otus*	BCC		Inhabit woodlands and conifer groves, favoring dense trees for nesting and roosting, and open country for hunting. Found in forests with extensive meadows, groves of conifers or deciduous trees in prairie country, or streamside groves in the desert. Typically avoids unbroken forests.	**Low** - May hunt or pass through, but will predominately nest and hunt outside study area in forested areas.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Bird - Raptor	Mexican Spotted Owl	*Strix occidentalis lucida*	T		Inhabits canyon and montane forests and rocky canyons from southern Utah, Colorado, Arizona, New Mexico, and western Texas. The highest densities of this species occur in mixed-conifer forests with minimal human disturbance.	**Low** - May hunt or pass through, but will predominately nest and hunt outside study area in forested, undisturbed areas.
Bird - Raptor	Northern Goshawk	*Accipiter gentilis*			Occupy coniferous and mixed forests, and are generally restricted to wooded areas but may also be found in open woods or edges. In the western U.S. they are found in the forest along riparian corridors and in more open habitat such as sagebrush steppes. Nest in mature, old-growth forests with more than 60% closed canopy throughout their entire range.	**Low** - May hunt or pass through incidentally, but will predominately nest and hunt outside study area in dense, forested areas.
Bird - Raptor	Peregrine Falcon	*Falco peregrinus*		T	Breeding territories located on cliffs in wooded/forested habitats; hunting habitats include croplands, meadows, riverbottoms, marshes and lakes.	**High** - Suitable hunting habitat present within the study area, and nesting habitat present along cliffs outside of the study area.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Fish	Rio Grande Chub	*Gila pandora*		NM sensitive	Most commonly found in flowing pools of headwaters, creeks, and small rivers near inflow of riffles, undercut banks, aquatic vegetation, and plant debris. Can also occur in impoundments.	**None -** No suitable habitat present within the study area.
Fish	Zuni Bluehead Sucker	*Catostomus discobolus yarrowi*	E	E	Most frequently occurs in stream reaches with cobble and bedrock substrates with slow- to moderate-velocity water. In New Mexico, the sucker currently is limited to the headwaters of the Zuni River drainage.	**None -** No suitable habitat present within the study area.
Invertebrate	Socorro Mountainsnail	*Oreohelix neomexicana*		NM sensitive	Occupies a variety of habitats from lush forested canyons to extreme conditions. Found in New Mexico in scant cover under loose stones, limestone rocks, and other single stones in areas of rich leaf litter.	**None -** No suitable habitat present within the study area.
Mammal	Cebolleta Pocket Gopher	*Thomomys bottae paguatae*		NM sensitive	Currently known only from a small area in Cibola County. Prefers perennial riparian vegetation including willow, cottonwood, alder, and maple. Surrounding uplands in known locality include large sandstone cliffs with juniper, piñon, and sage.	**Low** - Evidence of gophers identified in the project area, but unlikely this species due to its preference for riparian habitat.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Mammal	Common Hog-nosed Skunk	*Conepatus leuconotus*		NM sensitive	Inhabits a variety of habitats including sycamore, cottonwood, and rabbitbrush riparian habitats, pinion-juniper woodlands, and montane shrublands. Prefers rocky areas. Uses rock crevices, hollow logs, underground burrows, caves, mines, woodrat houses, or buildings as dens.	**Medium -** Potential for habitat to be present.
Mammal	Gunnison's prairie dog (prairie subspecies)	*Cynomys gunnisoni zuniensis*		NM sensitive	Found in plains and desert grassland, and to a lesser extent the Great Basin desert scrub. Occurs in low valleys, but also is common in parks and meadows in the montane forests up to at least 10,000 feet.	**Medium** - Potential for habitat to be present as there are numerous prairie dog colonies. Species needs to be confirmed.
Mammal	Northern Pocket Gopher	*Thomomys talpoides taylori*		NM sensitive	Found in a wide variety of habitats ranging from sagebrush steppe, mountain meadows, tundra, agricultural fields, grasslands, and gardens or lawns. Prefer deep soils along streams, meadows, and cultivated fields. Also found in rocky soils and clay.	**High** - Evidence of gophers identified in the project area.

Table 3-3. Wildlife Species of Interest

Type of Wildlife	Common Name	Scientific Name	Federal Status	State Status	Habitat/Seasonal Occurrence	Likelihood of Occurrence
Mammal	Red Fox	*Vulpes vulpes*		NM sensitive	Occupies a wide range of habitats including grasslands, deserts, mountains, forests, and suburban areas. Prefer wooded areas but can adapt to different environments.	**Medium -** Potential for habitat to be present.
Mammal	Ringtail	*Bassariscus astutus*		NM sensitive	Found in a variety of habitats such as semi-arid oak forests, pinyon pine or juniper woodlands, montane conifer forests, chaparral, desert, dry tropical habitats, and rocky or cliff areas. This species adapts well to disturbed areas and frequently found in human populated areas.	**Medium -** Potential for habitat to be present.
Reptile	Southwestern Fence Lizard	*Sceloporus cowlesi*		NM sensitive	Found in a variety of habitats including semidesert grasslands, woodlands, rocky canyons, and forested slopes. Usually encountered in open, sunlit areas with plenty of basking sites such as rock piles, wood piles, and fallen logs.	**Medium -** Potential for habitat to be present.

Notes: Queried from Bison-M, http://bison-m.org/index.aspx, January 2018, and USFWS IPAC for Cibola County, https://ecos.fws.gov/ipac/, January 2018.

T = threatened; E = endangered; BCC= bird of conservation concern; NM = New Mexico

Source: Lone Mountain, 2018

Table 3-4. Grants-Milan Municipal Airport Monthly and Annual Temperature and Precipitation for 1953-2012

Month	Average Minimum Temperature (°F)	Average Maximum Temperature (°F)	Average Monthly Precipitation (inches)
January	14.3	46.4	0.50
February	18.6	51.6	0.43
March	23.8	58.8	0.52
April	30.3	67.6	0.45
May	39.1	76.7	0.51
June	47.7	86.9	0.56
July	55.3	88.7	1.72
August	53.2	85.7	2.01
September	44.7	80.1	1.29
October	32.7	69.9	1.09
November	22.0	56.9	0.55
December	14.5	47.4	0.67
Annual Average Temperature/Total Precipitation	33.0	68.1	10.29

Source: Western Regional Climate Center, Grants-Milan Municipal Airport, New Mexico (293682). Period of Record: 05/01/1953 to 11/03/2012. Retrieved from https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?nm3682 on April 10, 2019.

Table 3-5 Grants Reclamation Project Meteorological Data 2018

Month	Simple Stats	Wind Speed (m/s)	Air Temperature (c)	Relative Humidity (%)	Monthly Precipitation (in)	Net Solar Radiation (W/m²)	Average Daily Temp (c)	Calculated Heat Index	Evaporation Potential (cc/month)
Jan-17	*max*	11.1	17.1	90.3	0.06	101.7	0.00	0.00	0.00
	min	0.2	-17.1	7.0					
	mean	2.7	-0.3	43.4					
Feb-17	*max*	15.5	17.3	94.0	0.22	120.1	2.34	0.32	0.54
	min	0.2	-14.8	6.1					
	mean	3.5	2.3	45.2					
Mar-17	*max*	14.6	20.5	94.3	0.33	158.1	5.64	1.20	2.03
	min	0.2	-13.2	4.9					
	mean	3.6	5.6	36.1					
Apr-17	*max*	18.1	24.0	80.6	0.07	191.9	11.87	3.70	5.55
	min	0.0	-4.0	2.9					
	mean	4.8	11.9	21.3					
May-17	*max*	13.7	29.7	83.1	1.16	220.1	16.85	6.29	9.61
	min	0.0	-2.5	2.8					
	mean	3.6	16.8	20.3					
Jun-17	*max*	12.2	33.9	87.1	0.49	224.4	22.50	9.75	13.91
	min	0.2	6.9	4.4					
	mean	3.3	22.5	19.9					
Jul-17	*max*	12.5	33.2	91.8	1.13	188.9	22.71	9.89	14.30
	min	0.1	11.7	6.6					
	mean	3.1	22.7	41.0					
Aug-17	*max*	11.5	33.0	94.7	1.29	172.5	21.11	8.85	12.28
	min	0.1	8.7	7.4					
	mean	2.8	21.1	43.0					
Sep-17	*max*	8.8	29.2	91.0	1.04	153.6	18.05	6.99	8.96
	min	0.2	3.2	7.3					
	mean	2.4	18.1	39.7					
Oct-17	*max*	9.8	23.8	93.5	1.22	101.3	9.69	2.72	3.80
	min	0.2	-1.3	11.7					
	mean	3.1	9.7	60.8					
Nov-17	*max*	10.7	17.0	84.3	0.02	100.7	2.12	0.27	0.48
	min	0.3	-14.5	7.3					
	mean	2.7	2.1	39.3					
Dec-17	*max*	12.3	15.1	94.2	0.35	77.5	0.00	0.00	0.00
	min	0.3	-21.0	7.5					
	mean	2.7	-1.3	58.4					

Net solar radiation = $(1-\alpha) \times SR$

α = albedo (Earth average around 0.35. Typical desert sands average 0.4 and grassses average 0.25. Going with a 0.33.

SR = solar radiation (From HMC met station data)

Evaporation Potential (PET) = $1.6 \times (L/12) \times (N/30) \times (10\,T_a/I)^{\alpha}$

T_a = Average daily temperature (degrees Celsius; if negative then value of 0) for month being calculated.

L = Average day length (in hours) of month being calculated.

N = number of days in month being calculated.

$\alpha = (6.75E\text{-}7) \times I^3 - (7.71E\text{-}5) \times I^2 + (1.792E\text{-}2) \times I + 0.49239$

α =	(a)	(b)	= a × b
	6.75E-07	124889.5	8.43E-02
	7.71E-05	2498.5	1.93E-01
	1.79E-02	50.0	8.96E-01
			0.49239
	α =		1.28E+00

$I = \Sigma$ *(for i = 1 to 12)* $(T_{ai}/5)^{1.514}$ = Heat index which depends on the 12 monthly mean temperatures (T_{ai}).

	I =	49.99

Source: HMC and Hydro-Engineering, 2019

Table 3-6 2010 Cibola County Demographics

Population Groups	Cibola County	
	Population	Percentage
Population	26,746	
Under 5 years		6.3
Under 18 years		23.6
65 years and over		16.1

	Cibola County		Grants	Milan	San Rafael
	Population	Percentage	Population	Population	Population
Total population (5-Year Estimate)	26,746		9094	3644	892
Hispanic or Latino		38.4%	4533	2584	671
White alone		51.8%	5785	2371	575
Black or African American alone		1.4%	163	69	
American Indian and Alaska Native alone		43.8%	1749	511	
Asian alone		0.6%	46	21	
Native Hawaiian and Other Pacific Islander alone		0.1%	0	0	
White alone not Hispanic or Latino.		19.1%	2562	636	221
Two or More Races		2.1%	291	46	

Labor	Cibola County	
In civilian labor force, total percent of population over 16years (2014-2018)		52.6%
In civilian labor force, female percent of population over 16years (2014 -2018)		52.1%

Income and Poverty	Cibola County		Grants	Milan	San Rafael
Median household income (in 2018 dollars)		$37,368	$35,671	$35,648	$64,470
Individuals below the poverty line		27.6%	26.7%	37.3%	2.4%

Source: 2010 Census Data, Census, 2019

Table 3-7. Occupational Monitoring Program requirements

Type of Sample	Number of Samples	Locations	Procedure	Frequency	Analytical Parameters
Lapel Personal Air Sample	As required by the RWP or at RSO discretion	As required by the RWP (2-3 L/min or equivalent)	SOP 11 (HP-1)	As required by the RWP or at RSO descrition	Alpha, Natural Uranium
Lapel Air Sampler Calibration	All units in use	N/A	Manufacturer Specifications	As required by the RWP	Flow rate
Release of Equipment	As required by RWP	Potentially Contaminated Equipment and Materials	SOP 12 (HP-4)	As required by the RWP	Alpha, Beta, Gamma
ALARA	N/A	As required by the RSO	HP-6[A]	N/A	As required by RSO
Respiratory Protection [B]	As required by RWP	As required by the RWP	N/A (HP-7) [B]	N/A	N/A
Bioassay	Entry/exit samples and as required by RWP	As required by the RWP	SOP 14 (HP-8)	Entry/exit samples and as required by RWP	Natural Uranium in urine
Instrument Calibration	Variable	Radiation Detection Instruments in use	SOP 16 (HP-10)	Annually	N/A
Dosimetry	As required by the RWP or at RSO descrition	Personnel	SOP 13 (HP-3)	As required by the RWP or at RSO descrition	Gamma
Personnel Contamination	As required by RWP	As required by the RWP	SOP 12 (HP-12)	As required by the RWP	Alpha
Radiation Protection Training	As required	HMC site	Taught by RSO or designee [C]	Initial and annual refresher for personnel that work in Controlled Areas	Training class and written test

A - In 2018, HP-6 was added to the current list of SOPS in the Radiation Protection Program (RPP) Manual as SOP 33.

B - Respiratory protection not expected to be necessary for current site decommissioning and reclamation activities. Procedure HP-7 has been inactivated and is not included in current RPP Manual or in the HMC Manual of Standard Practices.

C - Annual refresher training is given by the RSO for all regular HMO empolyees that work in Controlled Areas. Temporary contractors are generally trained by the Radiation Safety Technician (RST) as a designee of the RSO, often with the aid of the previously developed radiation safety video following testing.

RWP- Radiation Work Permit
RSO - Radiation Safety Officer
RST - Radiation Safety Technician
L/min - Liters per minute

Source: ERG, 2019

SUMMARY OF ESTIMATED COSTS
Comparison by Remedial Alternative

COST ESTIMATE SUMMARY
Table 7-1

Site: HMC Grants Reclamation Project
Location: Grants, NM
Phase: Groundwater Corrective Action Plan
Base Year 2020
For: 30 Years
Date: 12/11/2019

Alternative Descriptions:
1) No Action - Natural Attenuation
2) Groundwater Containment and Removal
3) Groundwater Containment and Removal and In Situ Treatment

PROJECT COST SCHEDULE & PRESENT VALUE ANALYSIS

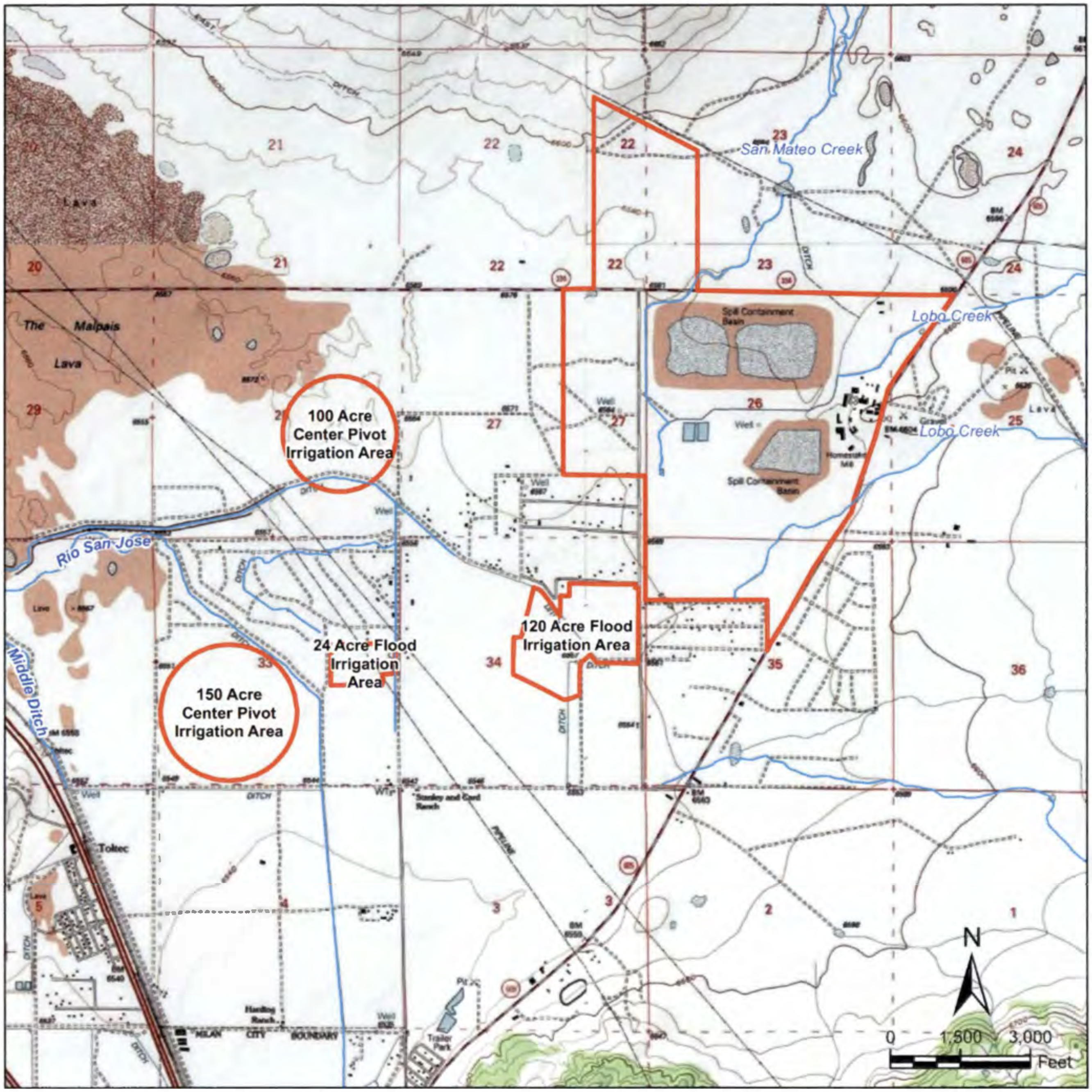
YEAR	DISCOUNT FACTOR	PERIOD CURRENT COSTS BY ALTERNATIVE			CUMULATIVE NPV BY ALTERNATIVE		
		1	2	3	1	2	3
0	1.000	$3,636,474	$9,479,069	$9,479,069	$3,636,474	$9,479,069	$9,479,069
1	0.887	$9,615,224	$9,479,069	$9,479,069	$12,164,760	$17,886,591	$17,886,591
2	0.787	$1,669,084	$9,479,069	$9,479,069	$13,477,814	$25,343,698	$25,343,698
3	0.698	$1,669,084	$9,479,069	$9,479,069	$14,642,437	$31,957,827	$31,957,827
4	0.619	$1,669,084	$9,479,069	$9,479,069	$15,675,407	$37,824,272	$37,824,272
5	0.549	$1,669,084	$15,979,069	$15,979,069	$16,591,606	$46,595,555	$46,595,555
6	0.487	$1,669,084	$9,214,574	$9,214,574	$17,404,234	$51,081,865	$51,081,865
7	0.432	$1,669,084	$9,214,574	$9,214,574	$18,125,001	$55,061,026	$55,061,026
8	0.383	$1,669,084	$8,791,844	$8,791,844	$18,764,289	$58,428,457	$58,428,457
9	0.340	$1,669,084	$8,791,844	$8,791,844	$19,331,310	$61,415,221	$61,415,221
10	0.301	$1,669,084	$8,528,504	$3,985,594	$19,834,233	$63,985,002	$62,616,147
11	0.267	$1,669,084	$29,528,504	$15,056,834	$20,280,304	$71,876,639	$66,640,160
12	0.237	$1,669,084	$14,431,369	$1,945,664	$20,675,950	$75,297,501	$67,101,367
13	0.210	$1,669,084	$7,931,369	$1,945,664	$21,026,870	$76,965,049	$67,510,437
14	0.186	$1,669,084	$7,931,369	$1,837,084	$21,338,121	$78,444,092	$67,853,017
15	0.165	$1,669,084	$7,931,369	$1,837,084	$21,614,187	$79,755,939	$68,156,870
16	0.147	$1,669,084	$7,931,369	$1,837,084	$21,859,046	$80,919,490	$68,426,375
17	0.130	$1,669,084	$7,931,369	$1,837,084	$22,076,225	$81,951,510	$68,665,414
18	0.115	$1,669,084	$7,931,369	$1,837,084	$22,268,853	$82,866,866	$68,877,431
19	0.102	$1,669,084	$7,931,369	$1,782,784	$22,439,706	$83,678,747	$69,059,923
20	0.091	$1,669,084	$7,931,369	$1,782,784	$22,591,245	$84,398,850	$69,221,785
21	0.081	$1,669,084	$7,931,369	$1,782,784	$22,725,654	$85,037,550	$69,365,350
22	0.071	$1,669,084	$7,931,369	$1,782,784	$22,844,868	$85,604,050	$69,492,685
23	0.063	$1,669,084	$7,931,369	$1,782,784	$22,950,607	$86,106,510	$69,605,626
24	0.056	$1,669,084	$3,636,474	$1,782,784	$23,044,392	$86,310,842	$69,705,800
25	0.050	$1,669,084	$9,615,224	$6,208,884	$23,127,575	$86,790,043	$70,015,237
26	0.044	$1,669,084	$1,669,084	$1,782,784	$23,201,355	$86,863,823	$70,094,043
27	0.039	$1,669,084	$1,669,084	$1,782,784	$23,266,795	$86,929,263	$70,163,941
28	0.035	$1,669,084	$1,669,084	$1,782,784	$23,324,837	$86,987,305	$70,225,937
29	0.031	$1,669,084	$1,669,084	$1,782,784	$23,376,318	$87,038,786	$70,280,924
30	0.027	$5,262,070	$5,262,070	$6,301,000	$23,520,273	$87,182,741	$70,453,301
Total	-	$65,248,120	$264,310,790	$161,844,150	$23,520,273	$87,182,741	$70,453,301

Table 7-2 Uranium Plume Acreage

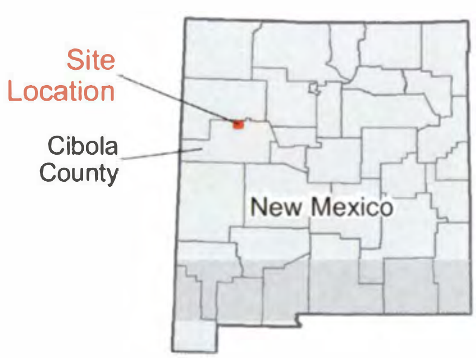
	Acres of Plume	Acres of Plume outside GRP Boundary
No Action Alternative		
Alluvial Aquifer over 0.16 mg/L Uranium	892	637
Upper Chinle Aquifer over 0.18/0.09 mg/L Uranium	241	12
Upper Chinle Aquifer over 0.16 mg/L Uranium	235	13
Alternative 2		
Alluvial Aquifer over 0.16 mg/L Uranium	103	0
Upper Chinle Aquifer over 0.18/0.09 mg/L Uranium	67.3	30
Upper Chinle Aquifer over 0.16 mg/L Uranium	38.3	0
Alternative 3		
Alluvial Aquifer over 0.16 mg/L Uranium	461	224
Upper Chinle Aquifer over 0.18/0.09 mg/L Uranium	152	27
Upper Chinle Aquifer over 0.16 mg/L Uranium	139	1
Difference in Alluvial Aquifer Alternative 1 and Alternative 2	789	637
Difference in Alluvial Aquifer Alternative 1 and Alternative 3	431	413
Difference in Upper Chinle Aquifer Alternative 1 and Alternative 2	196.7	13
Difference in Upper Chinle Aquifer Alternative 1 and Alternative 3	96	12

mg/L - Milligrams per liter

FIGURES



Source: USA Topo Maps: © 2013 National Geographic Society, i-cubed



LEGEND:

Rivers & Streams

Site Areas

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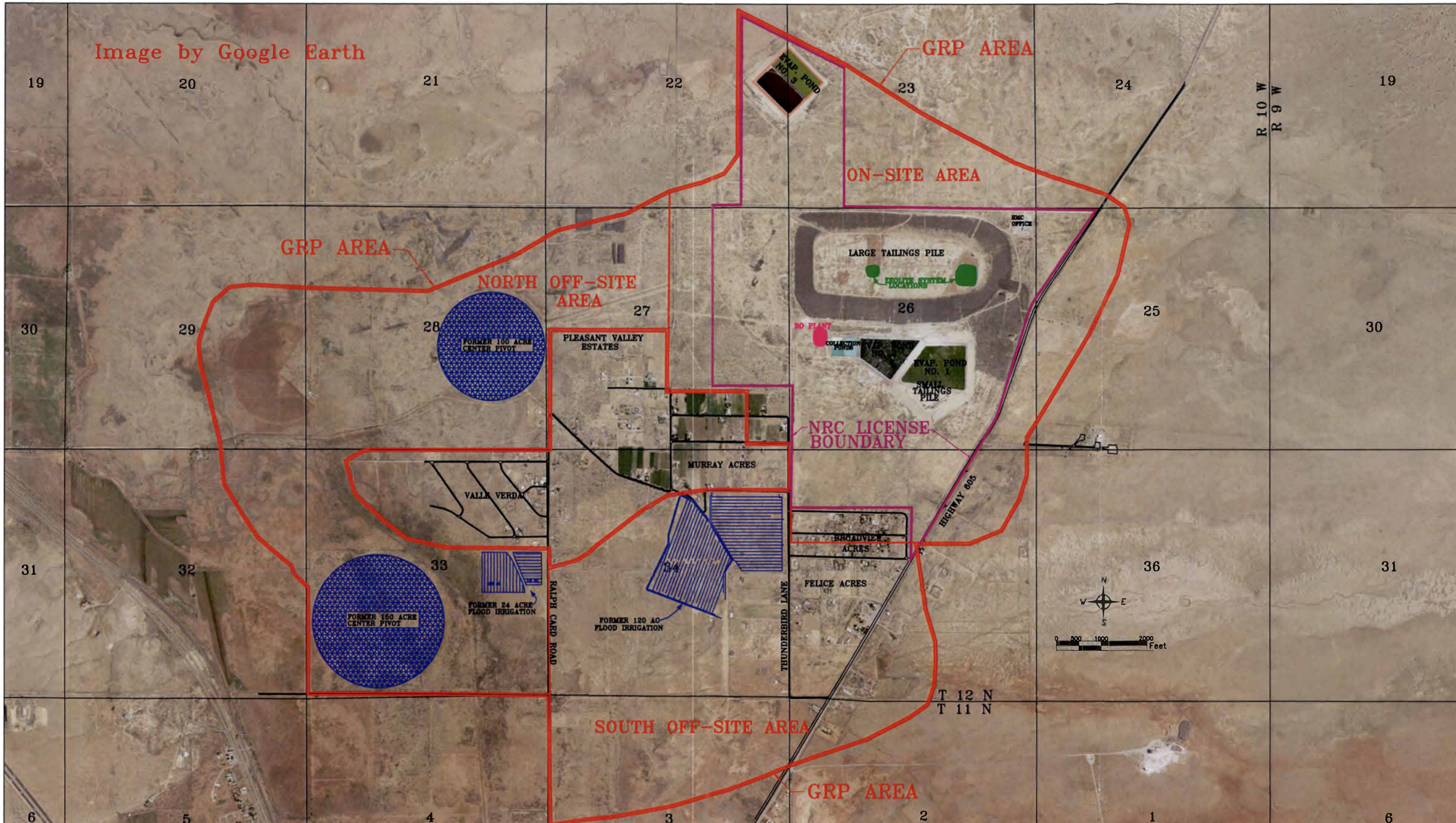
Figure 1-1
Grants Reclamation Project Location



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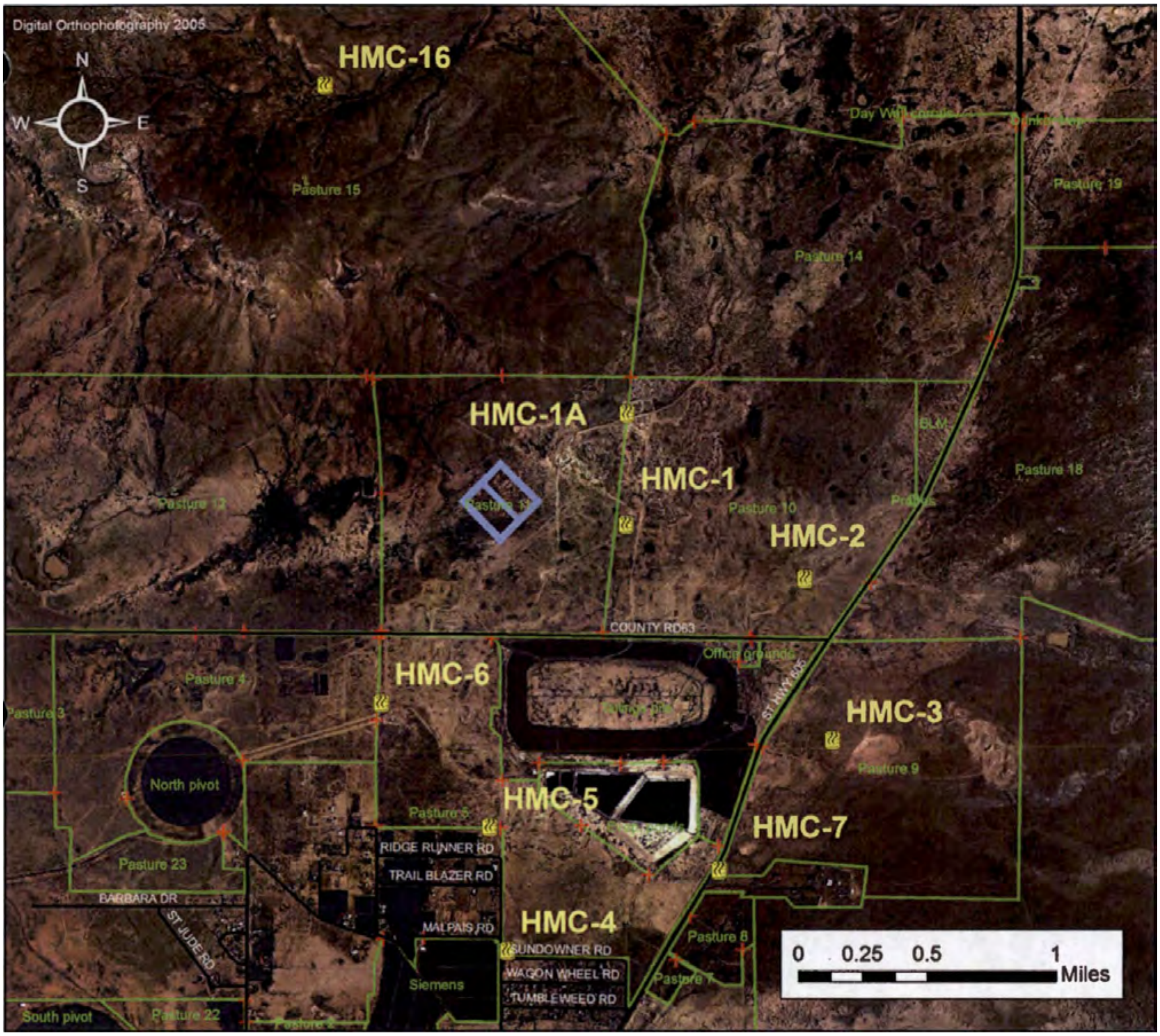
Corrective Action Program

FIGURE 1-2
Grants Reclamation Project
Features



Location ID	Sampling Unit	Northing	Easting
HMC-1	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1547458.8	491370.5
HMC-1A	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1549715.8	491387.7
HMC-2	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1546349.5	495053.2
HMC-3	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1543048.7	495640.5
HMC-4	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1538751.1	488918.0
HMC-5	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1541268.4	488546.3
HMC-6	Hi-Vol Particulate (Air), Track-Etch Cup (Radon), OSL Badge (Gamma)	1543813.1	486297.3
HMC-7	Track-Etch Cup (Radon)	1540395.7	493293.8
HMC-16	Track-Etch Cup (Radon), OSL Badge (Gamma)	1556470.5	485135.1

Location
Road
Gate
EP-3
Fence Line
Section Line

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Figure 1-3
Air Monitoring and Sampling Locations

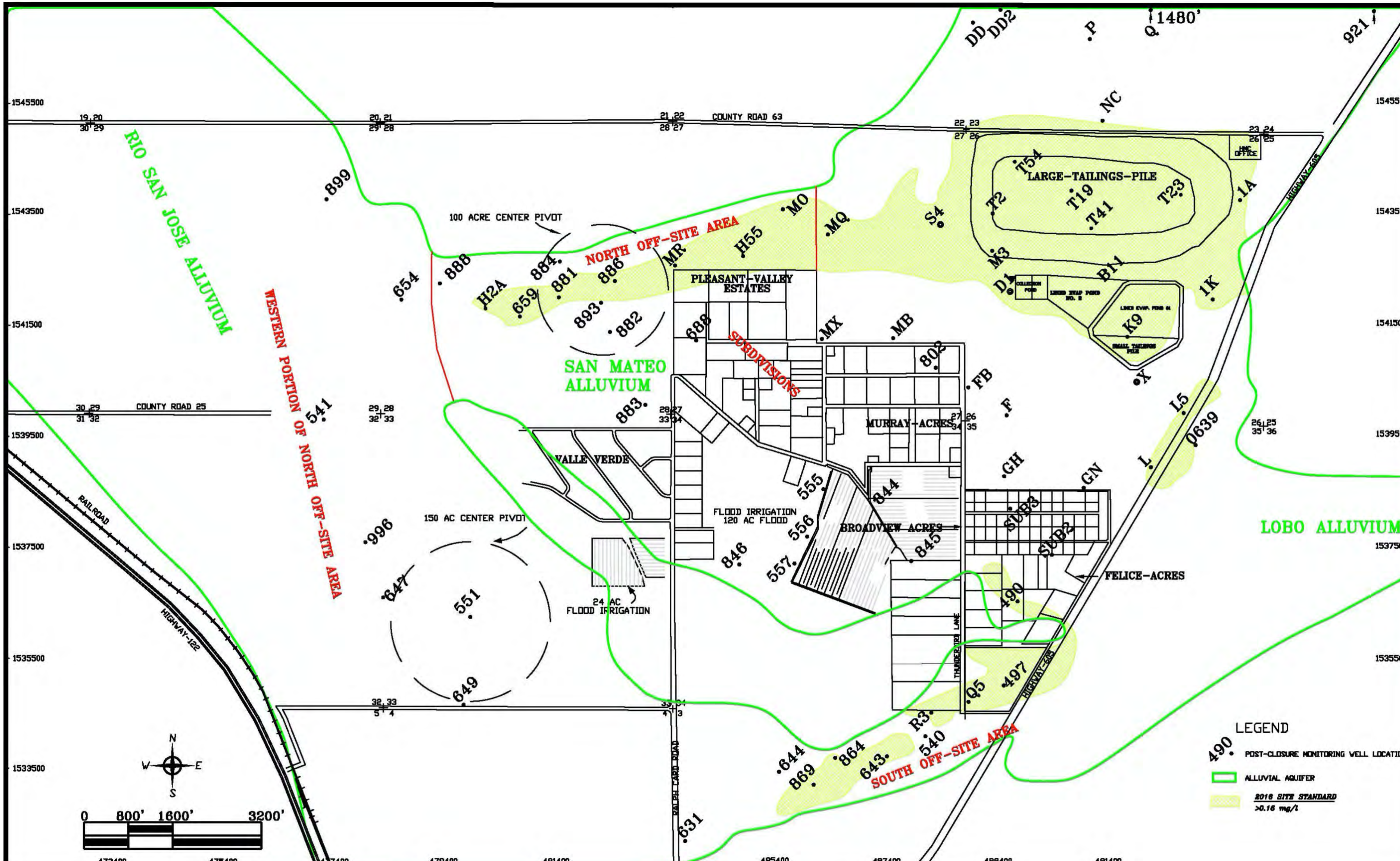

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Figure 1-4
Alluvial Aquifer Compliance Monitoring Well Locations

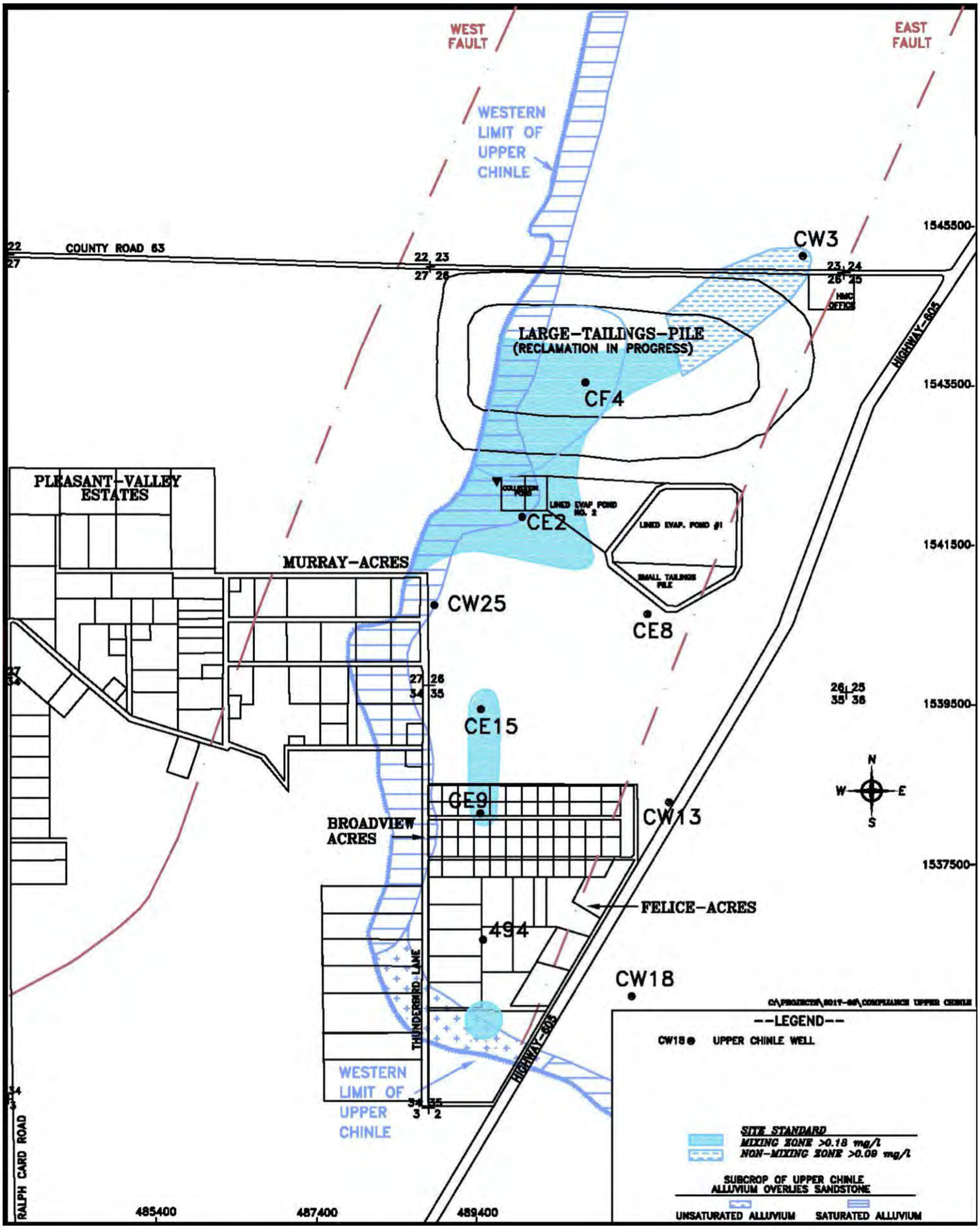

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Figure 1-5
Upper Chinle Aquifer Compliance Monitoring Well Locations

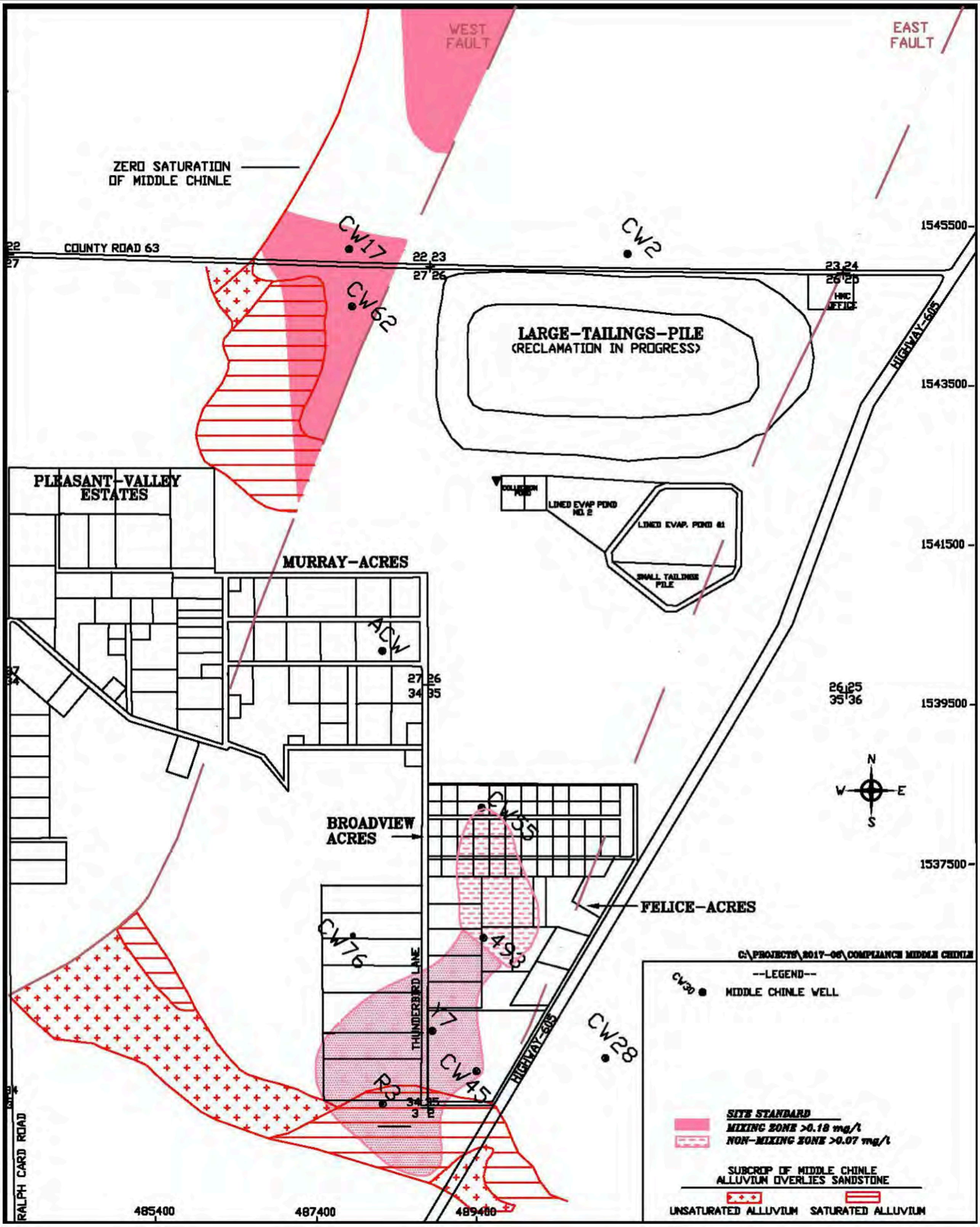

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Figure 1-6
Middle Chinle Aquifer Compliance Monitoring Well Locations

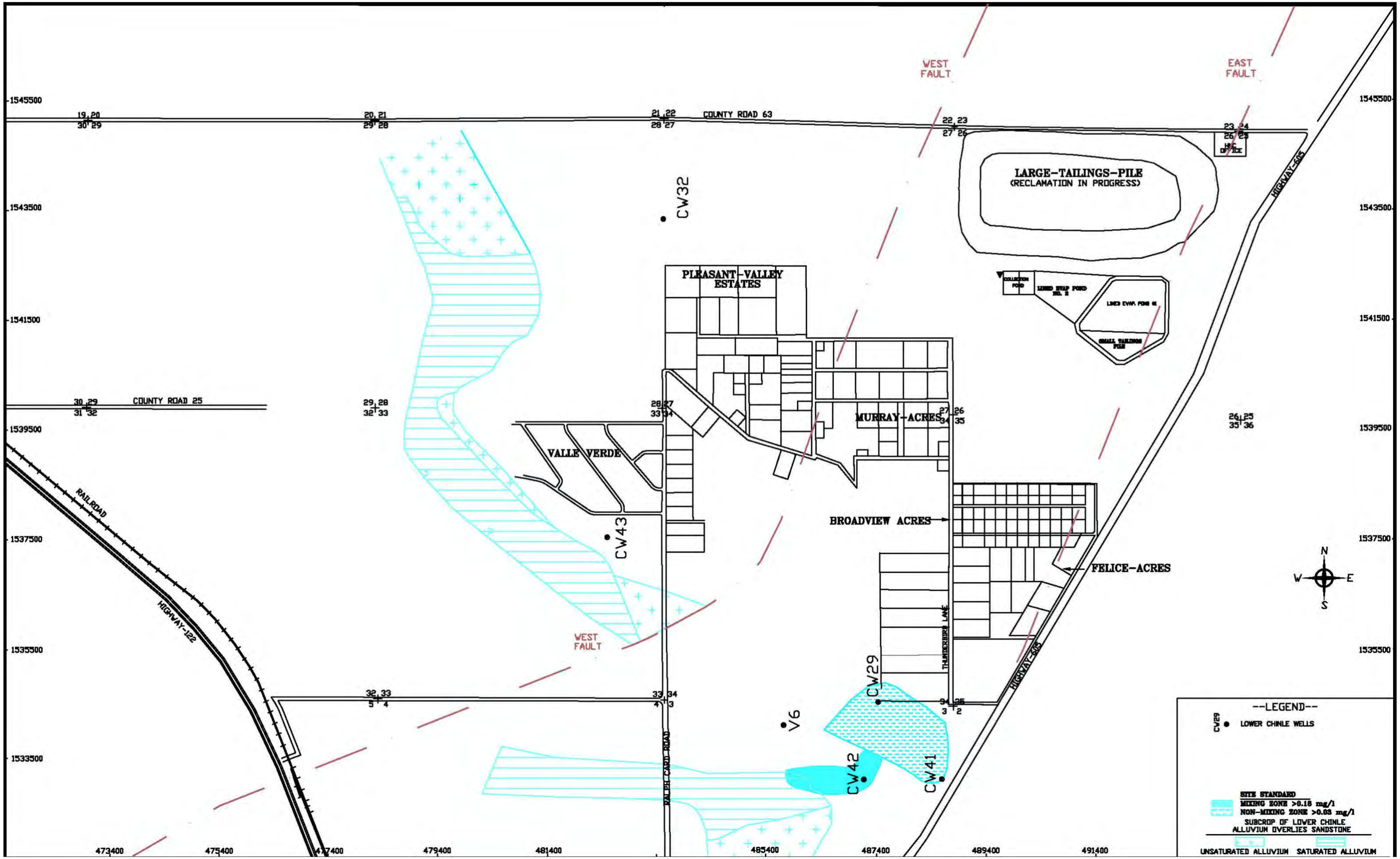

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Figure 1-7
Lower Chinle Aquifer Compliance Monitoring Well Locations

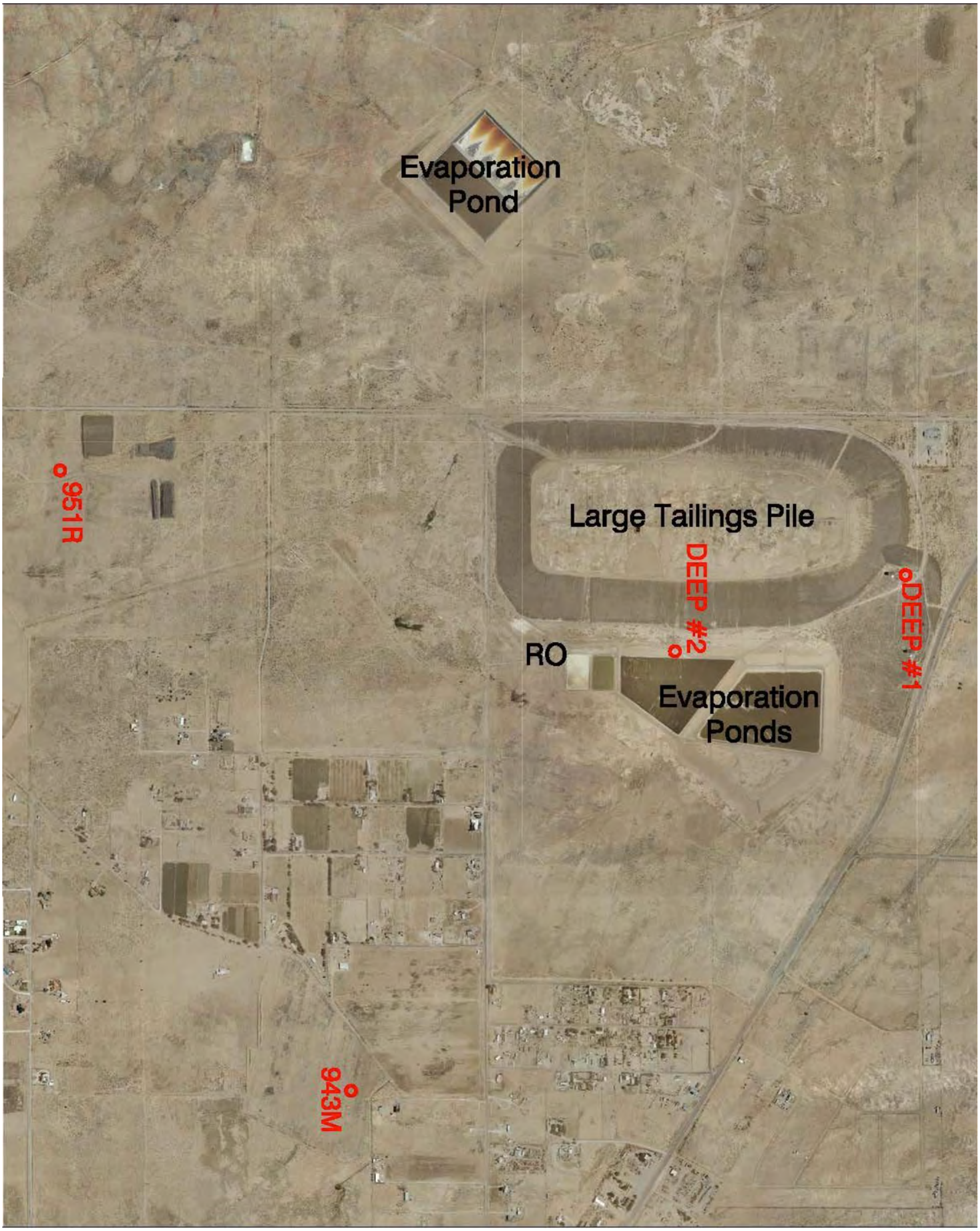

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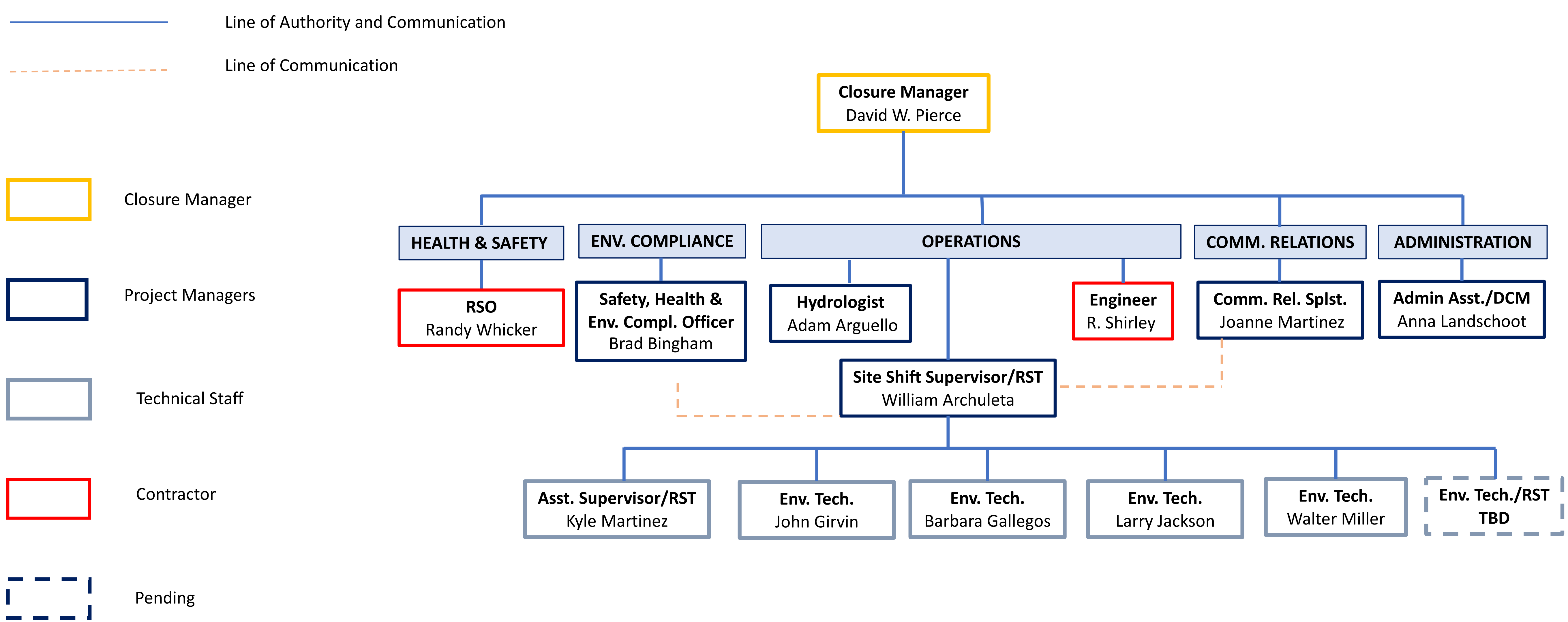
Figure 1-8
San Andres Aquifer Compliance Monitoring Well Locations



RST = Radiation Safety Technician   RSO = Radiation Safety Officer   DCM = Document Control Manager

Grants Reclamation Project
Corrective Action Program

Figure 1-9
Grants Reclamation Project
Organizational Chart

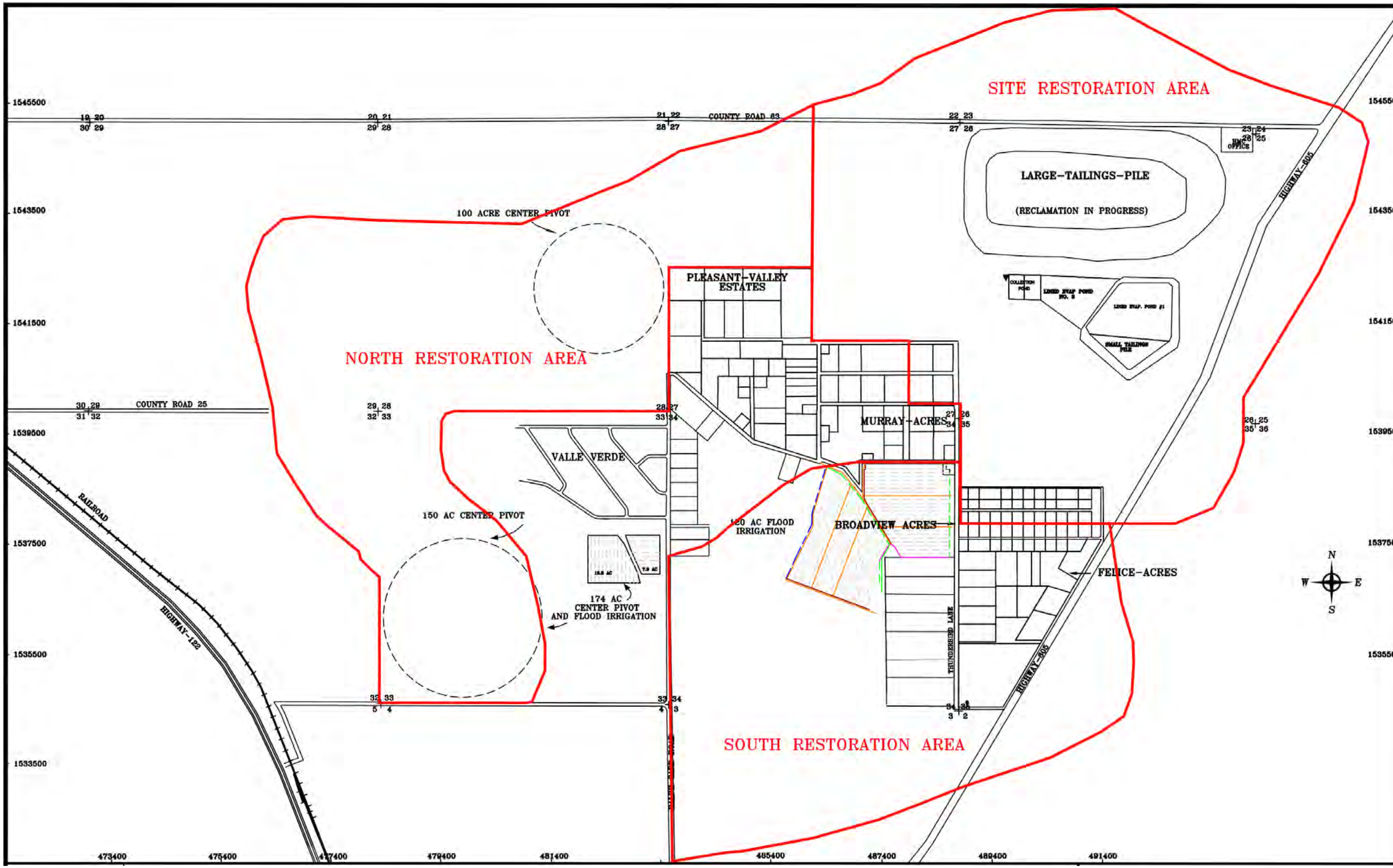


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Figure 2-1
Restoration Areas

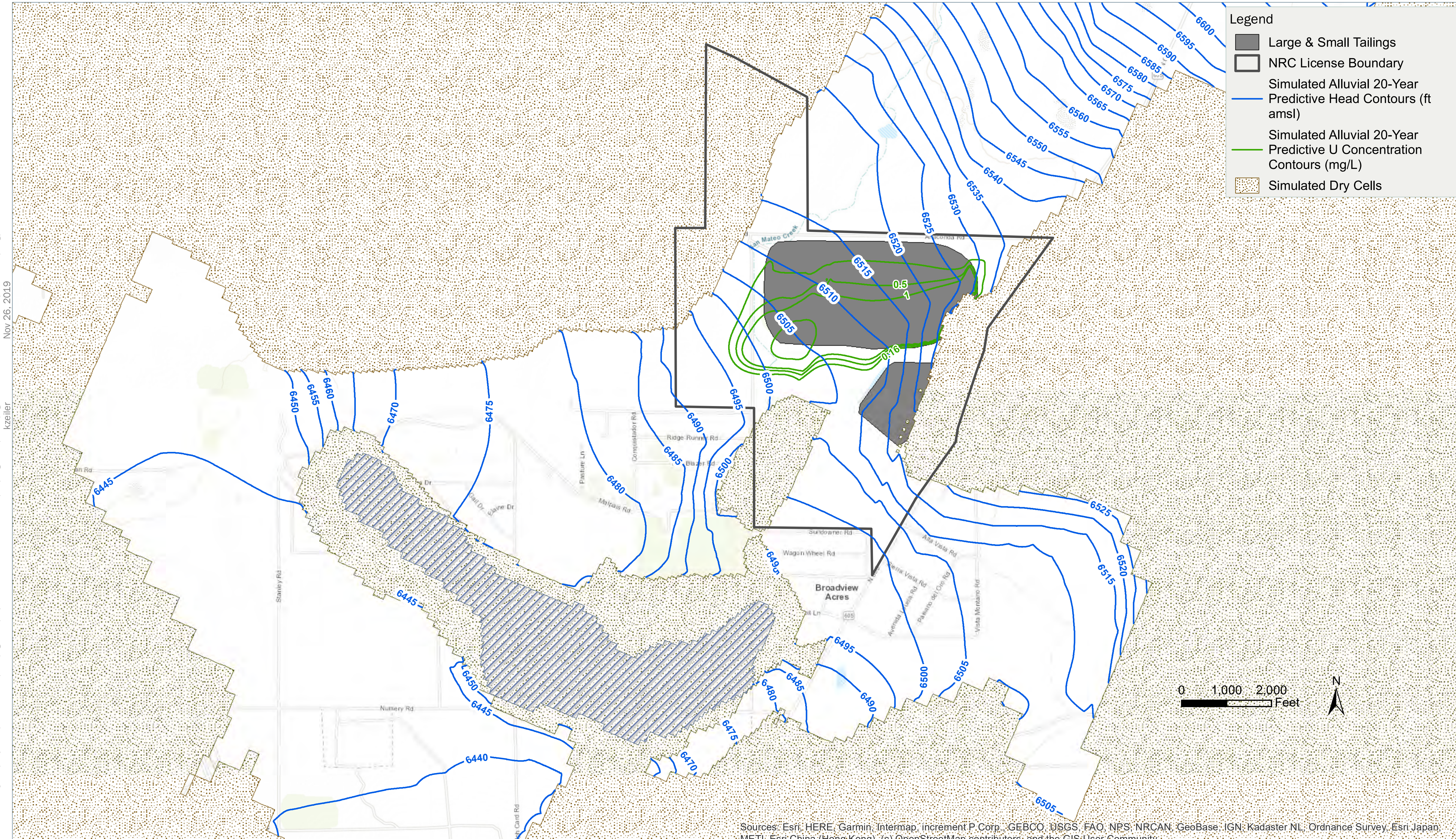

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Figure 2-2
Alluvial Aquifer Simulated Predictive 20-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

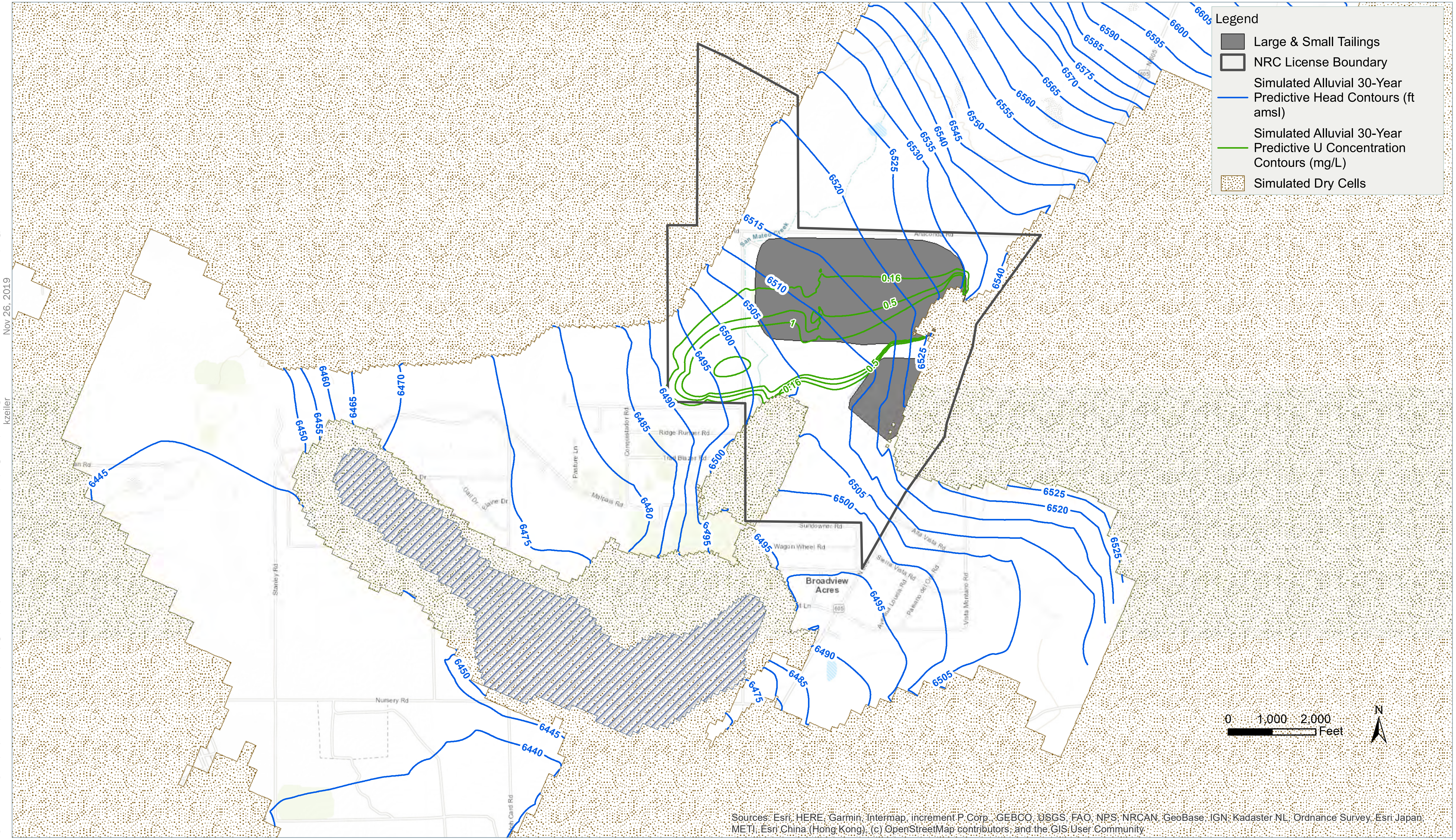

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Figure 2-3
Alluvial Aquifer Simulated Predictive 30-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

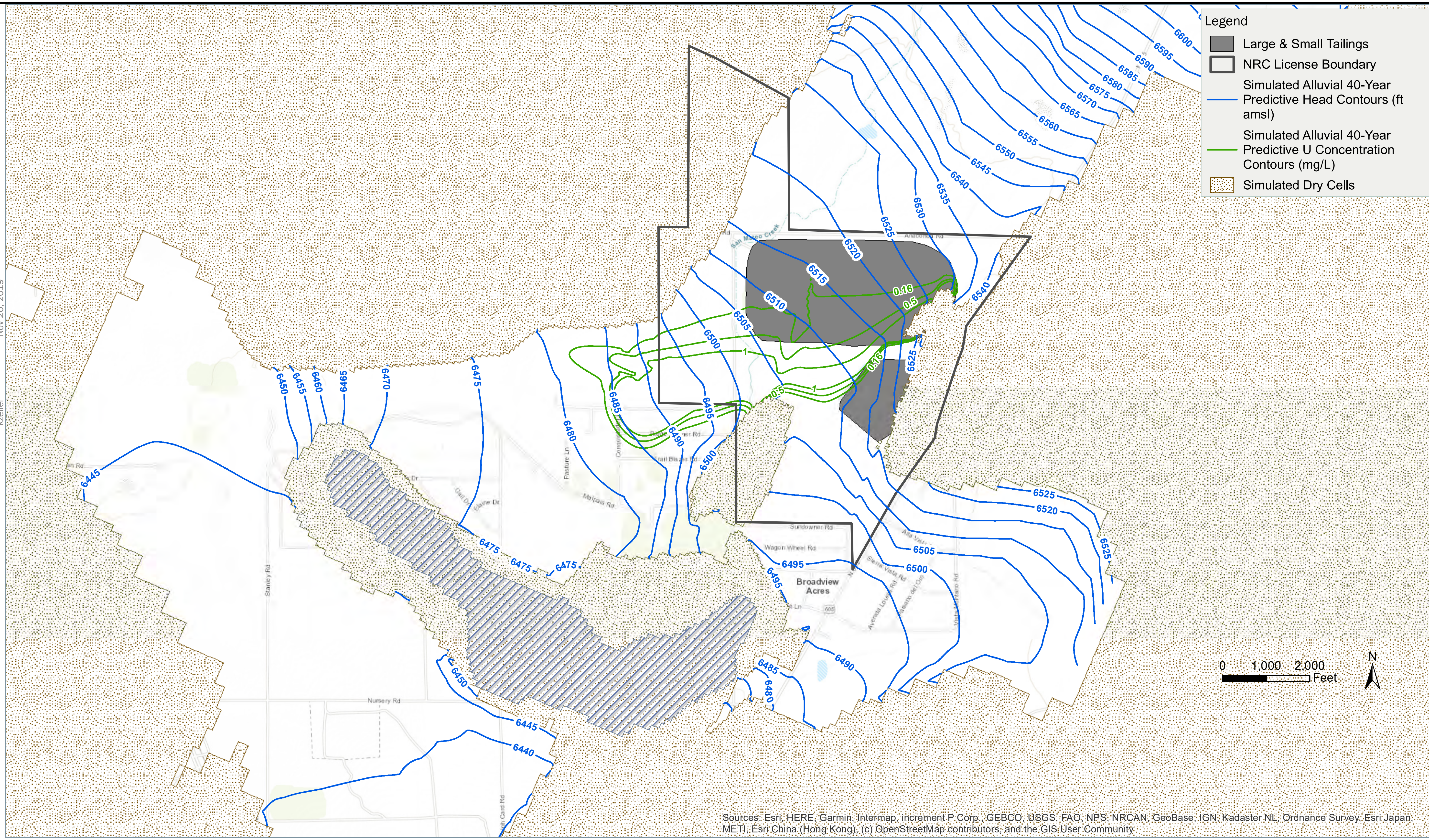

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Figure 2-4
Alluvial Aquifer Simulated Predictive 40-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

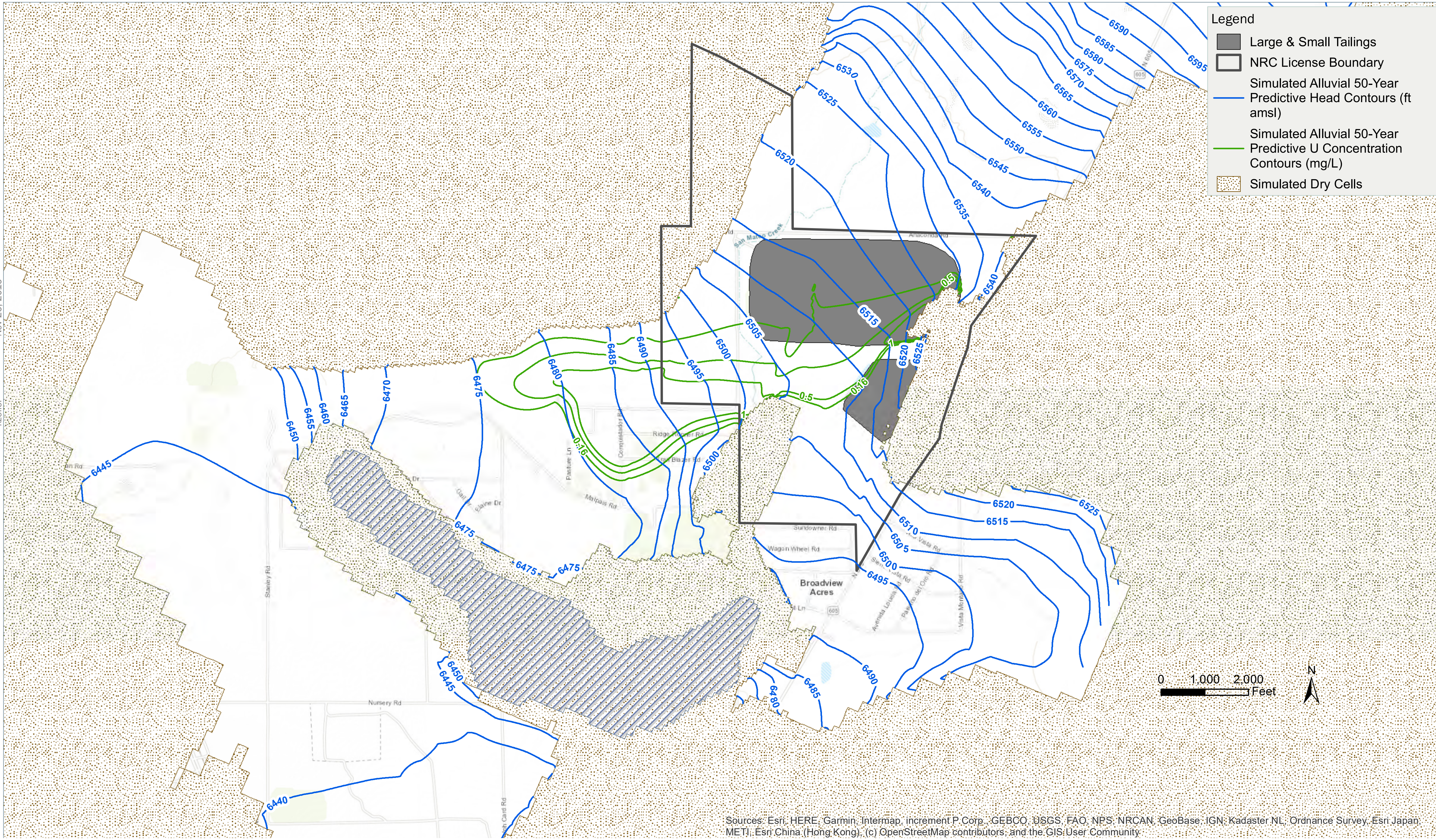

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Figure 2-5
Alluvial Aquifer Simulated Predictive 50-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

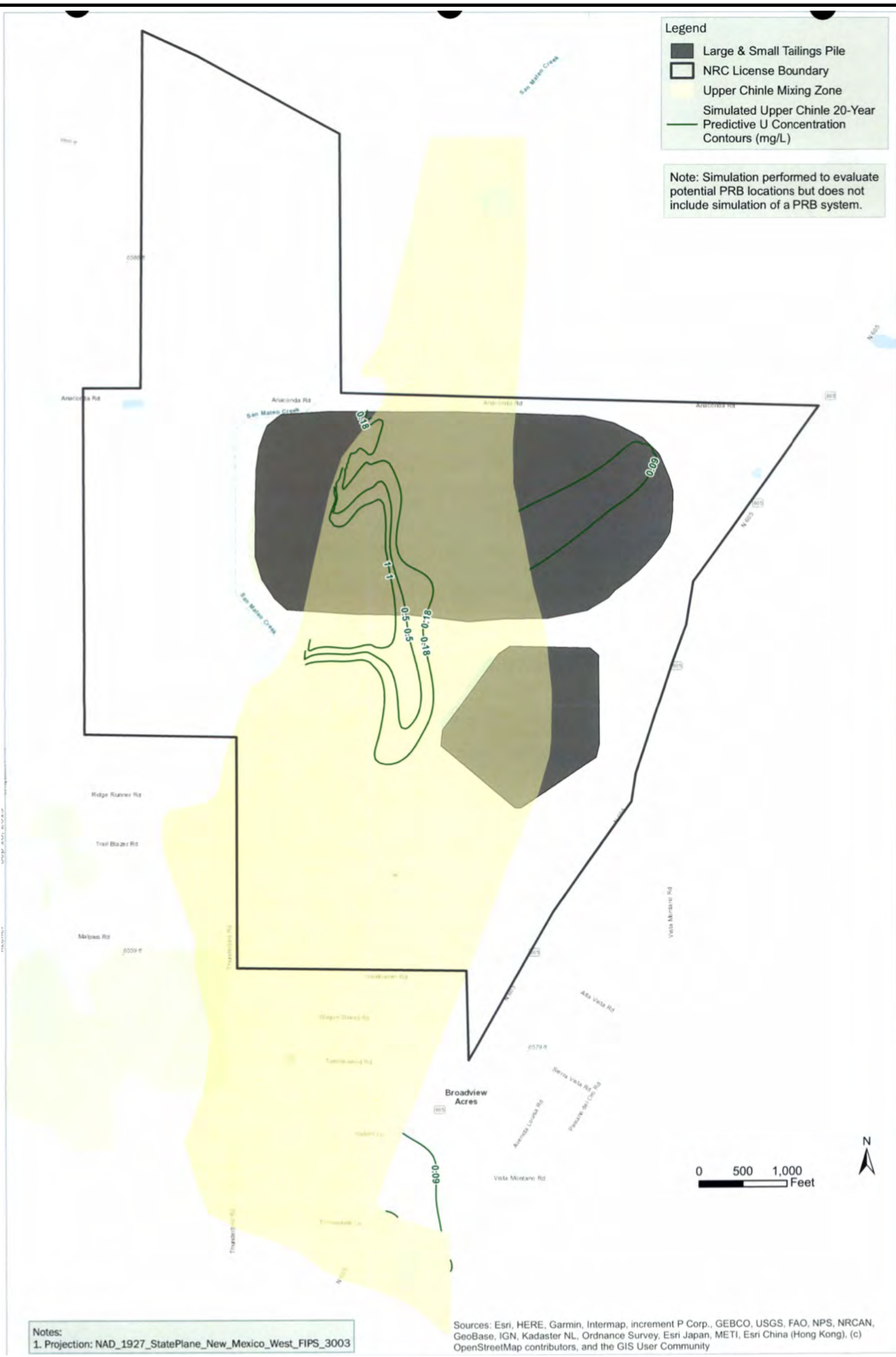

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Figure 2-6
Upper Chinle Aquifer Simulated Predictive 20-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

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Figure 2-7
Upper Chinle Aquifer Simulated Predictive 30-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

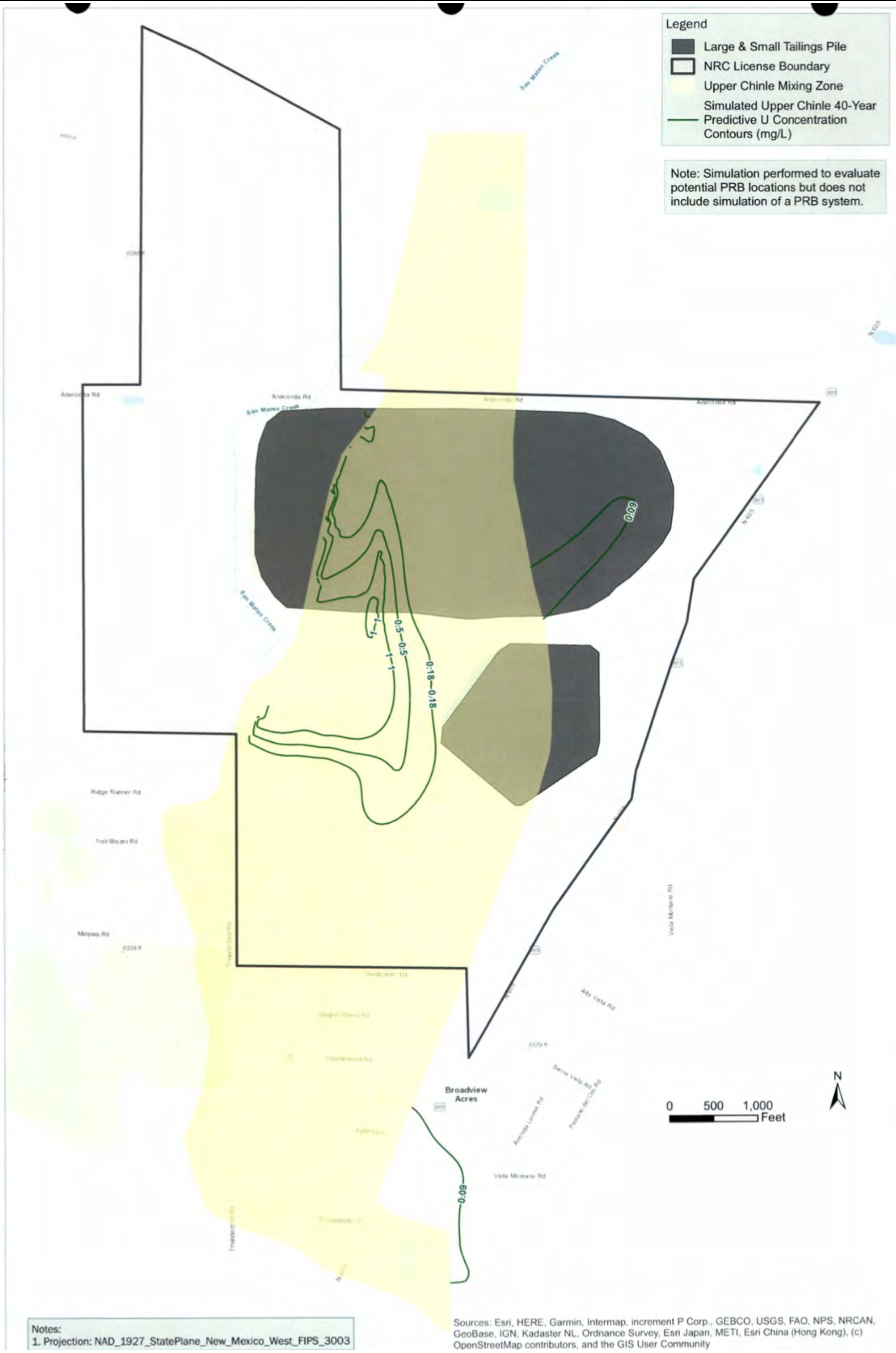

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Figure 2-8
Upper Chinle Aquifer Simulated Predictive 40-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

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Figure 2-9
Upper Chinle Aquifer Simulated Predictive 50-Year Uranium Concentration Contours with 10 Years of Active Groundwater Collection and Injection

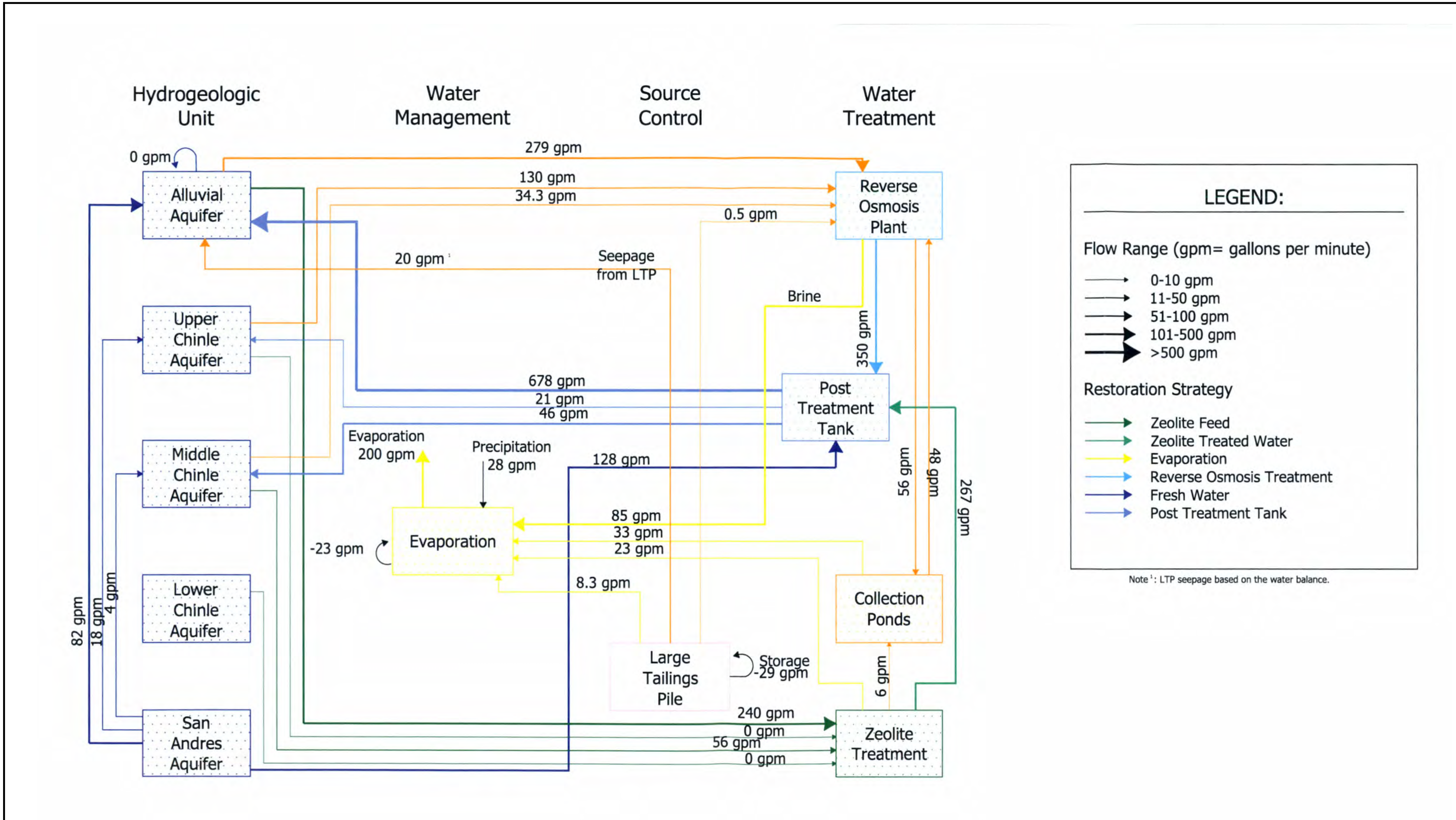

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Figure 2-10
2018 Major Operational Average Flows

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Figure 2-11
Locations of the GRP Evaporation Ponds, RO Plant and Zeolite Cells

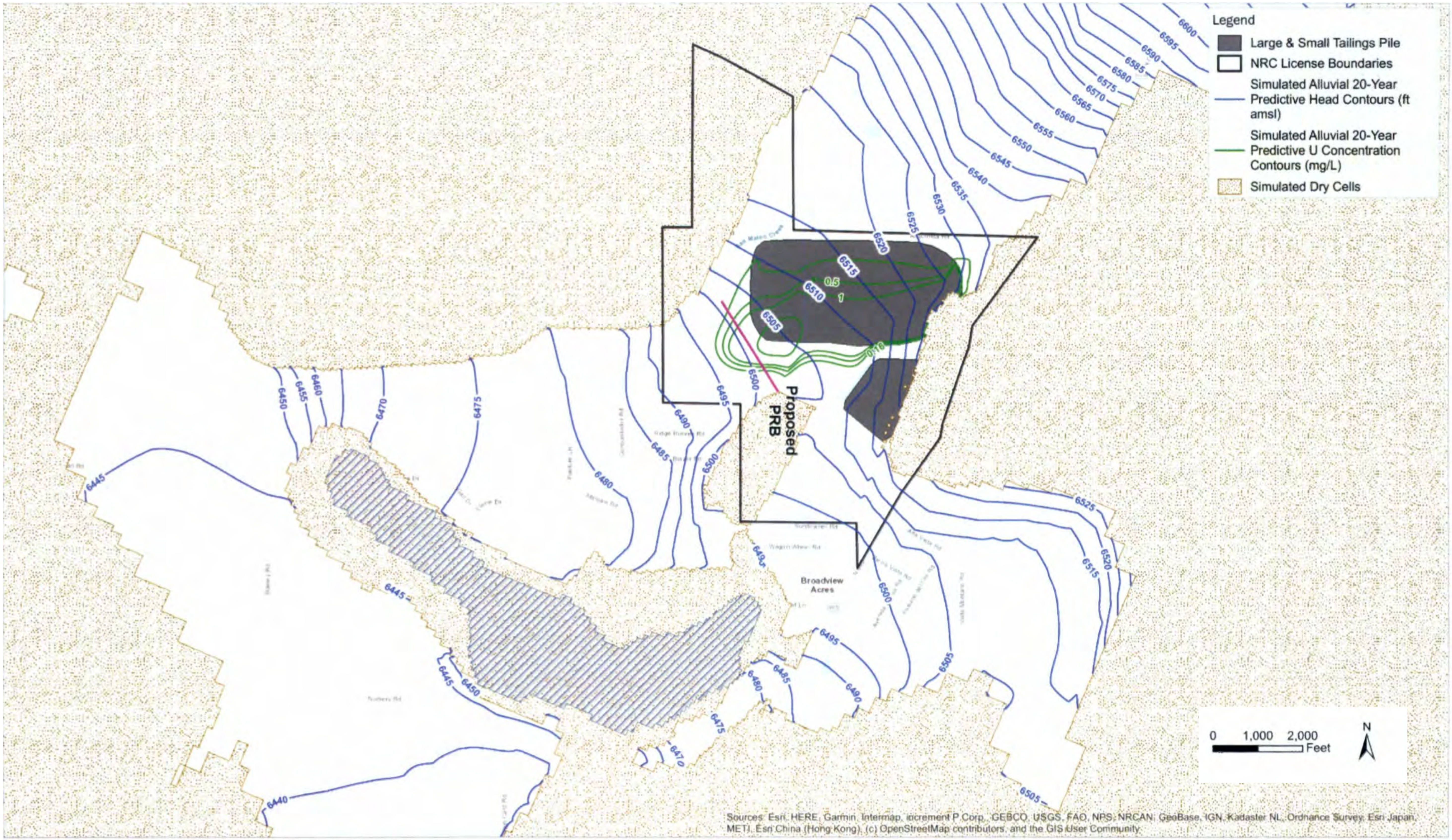

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Figure 2-12
Proposed Location of Permeable Reactive Barrier in Alluvial Aquifer at Toe of Large Tailings Pile

Notes:
1. Projection: NAD_1927_StatePlane_New_Mexico_West_FIPS_3003

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Figure 2-13
Proposed Location of Permeable Reactive Barrier in Upper Chinle at Toe of Large Tailings Pile

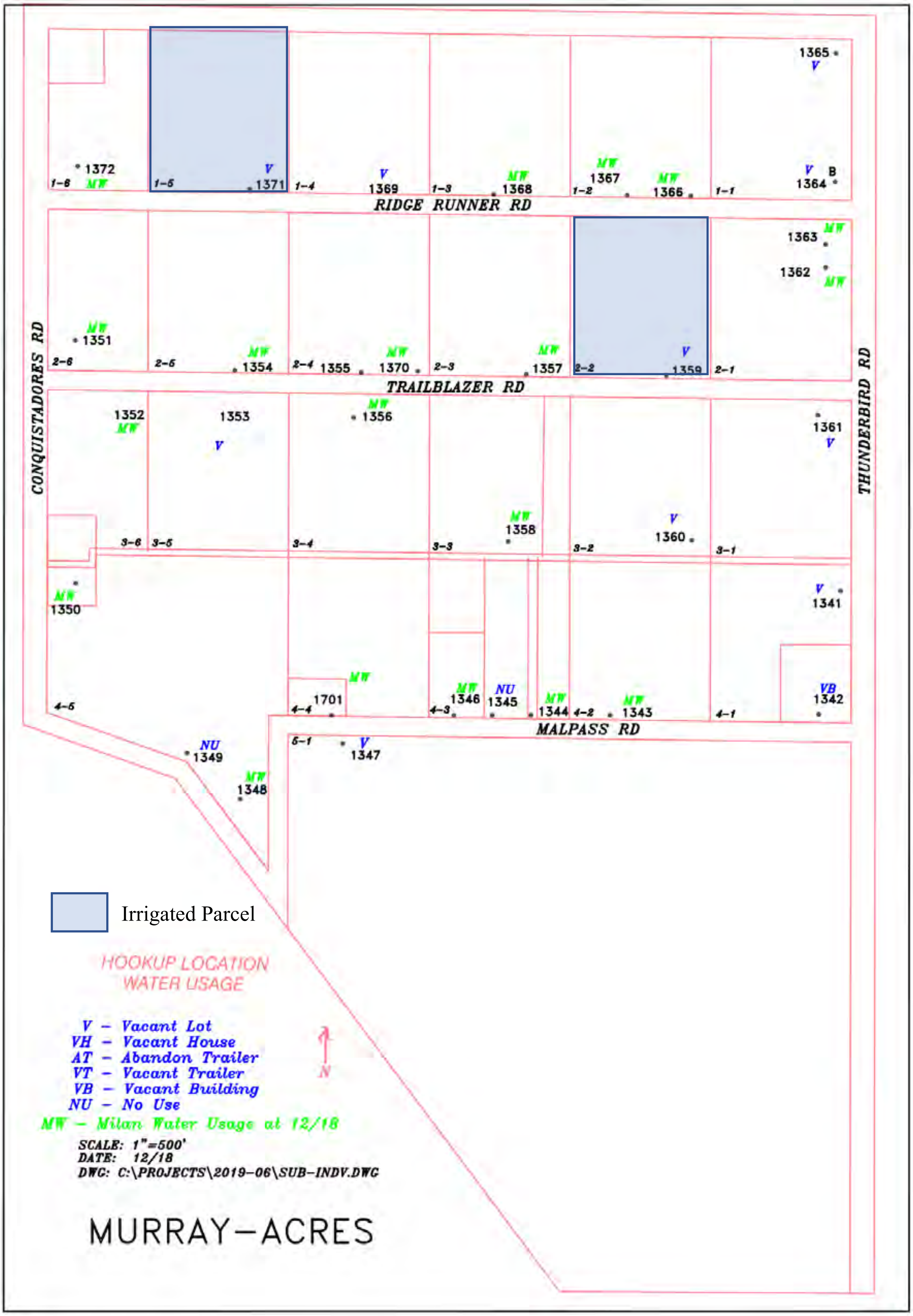

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Figure 3-1
Irrigated Parcels in Murray Acres

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Figure 3-2
Transportation Corridors

Cultural Study Location No.	Date	Reference
1	August 1993	SAC 1993a
2	December 1993	SAC 1993b
3	March 1994	SAC 1994
4	August 1994	CASA 1994a
5	Sept/Oct 1994	CASA 1994b
6	Sept/Oct/Nov/Dec 1994	CASA 1994c
7	April 1995	CASA 1995
8	June 2006	TEC 2006
9	Dec 2017/Jan 2018	LONE MOUNTAIN 2018

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Figure 3-3
Cultural Survey Areas

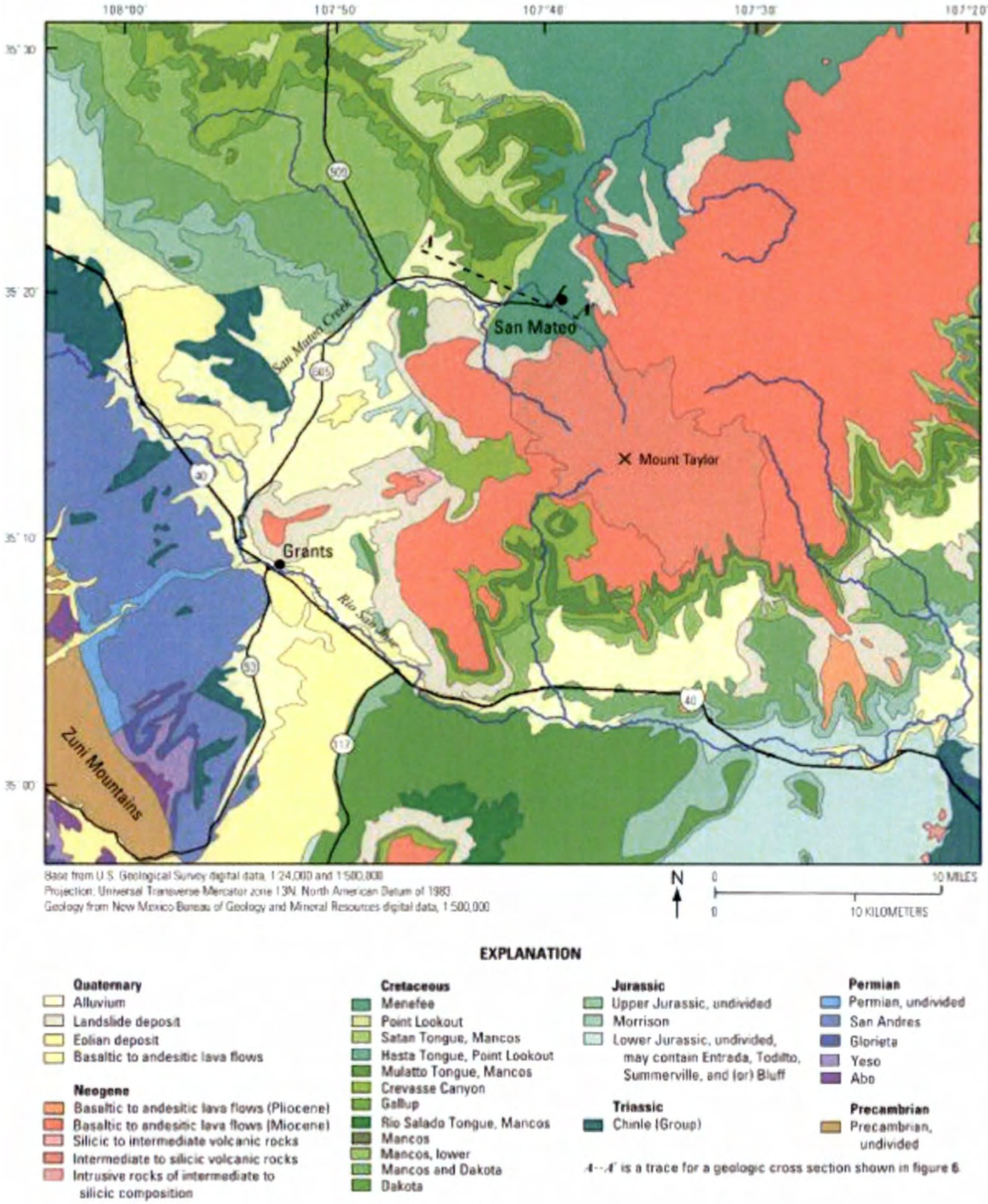
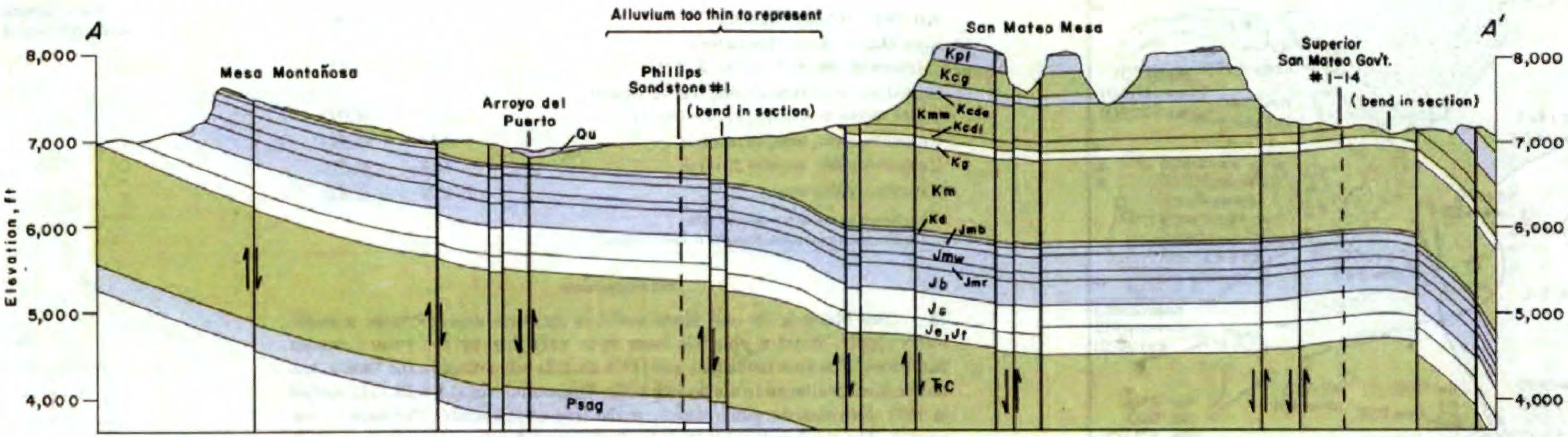


Figure 3-4
Surface Geology of the
San Mateo Creek Basin



CROSS SECTION—Unit thicknesses from measured section by Brod (1979, Appendix C, section 1) and logs from wells shown.

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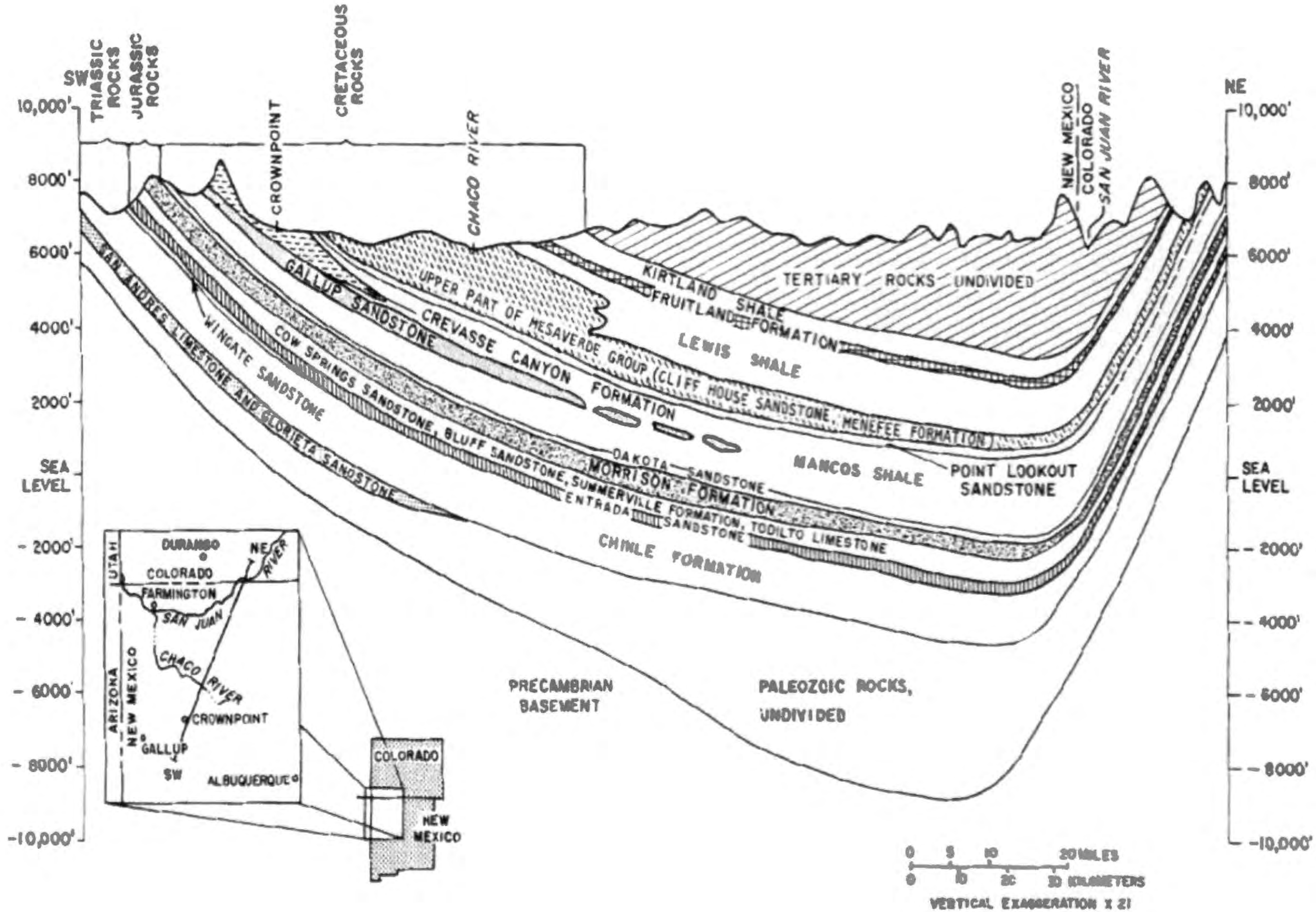
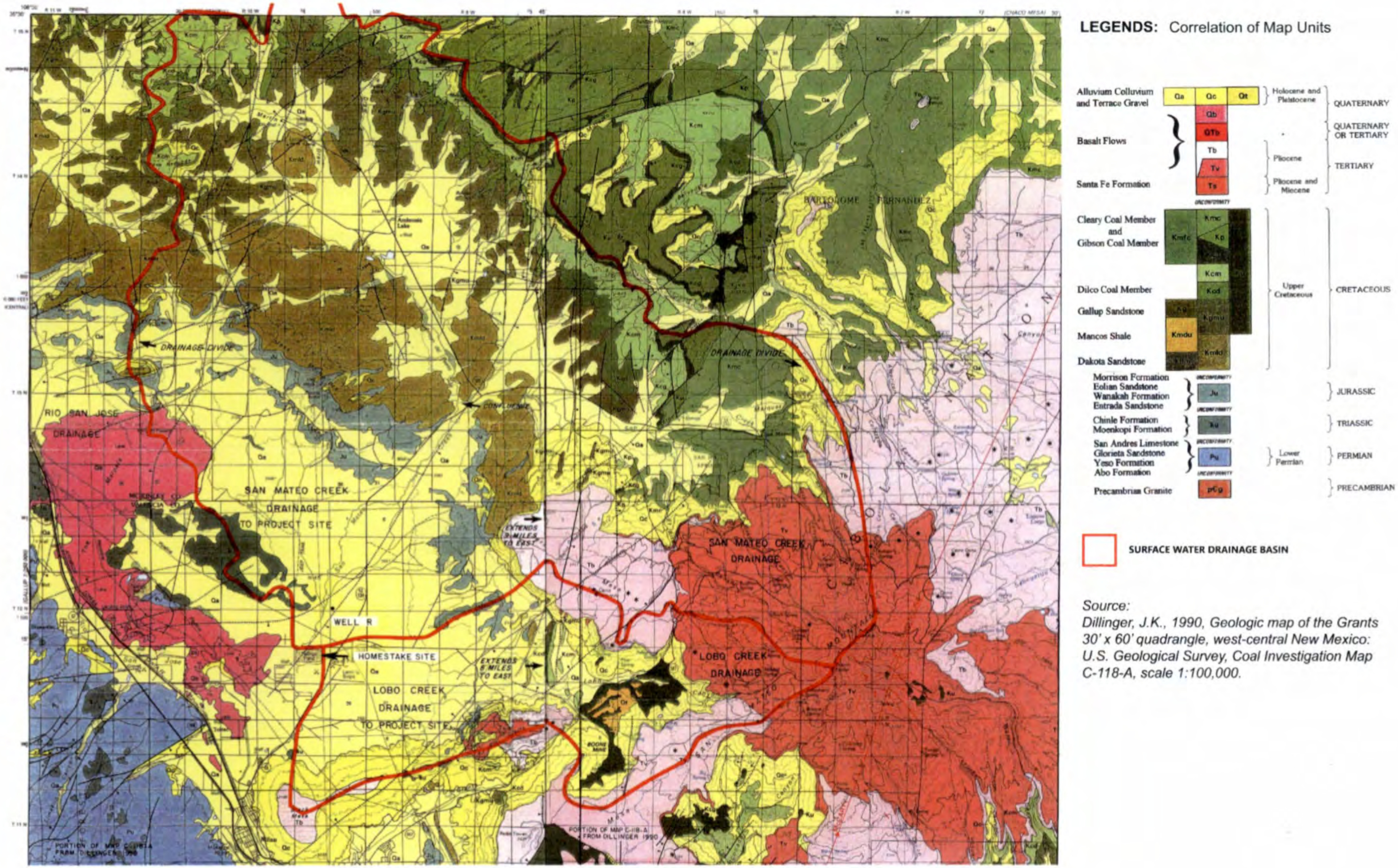
Source: Brod and Stone, 1981

Figure 3-5
Hydrogeologic Cross Section
Through the San Mateo Basin



Source: Frenzel and Lyford, 1982

Figure 3-6
Regional Geologic Cross Section Through the San Juan Basin



Source:
Dillinger, J.K., 1990, Geologic map of the Grants 30' x 60' quadrangle, west-central New Mexico: U.S. Geological Survey, Coal Investigation Map C-118-A, scale 1:100,000.

Grants Reclamation Project
Corrective Action Program

Figure 3-7
Regional Surface Water Drainage Basins

LEGEND:

Hydrogeologic Cross Section Line

Fault

N

0 1,250 2,500 Feet

Aerial: Bing Maps - © 2010 Microsoft Corporation and its data suppliers

Source: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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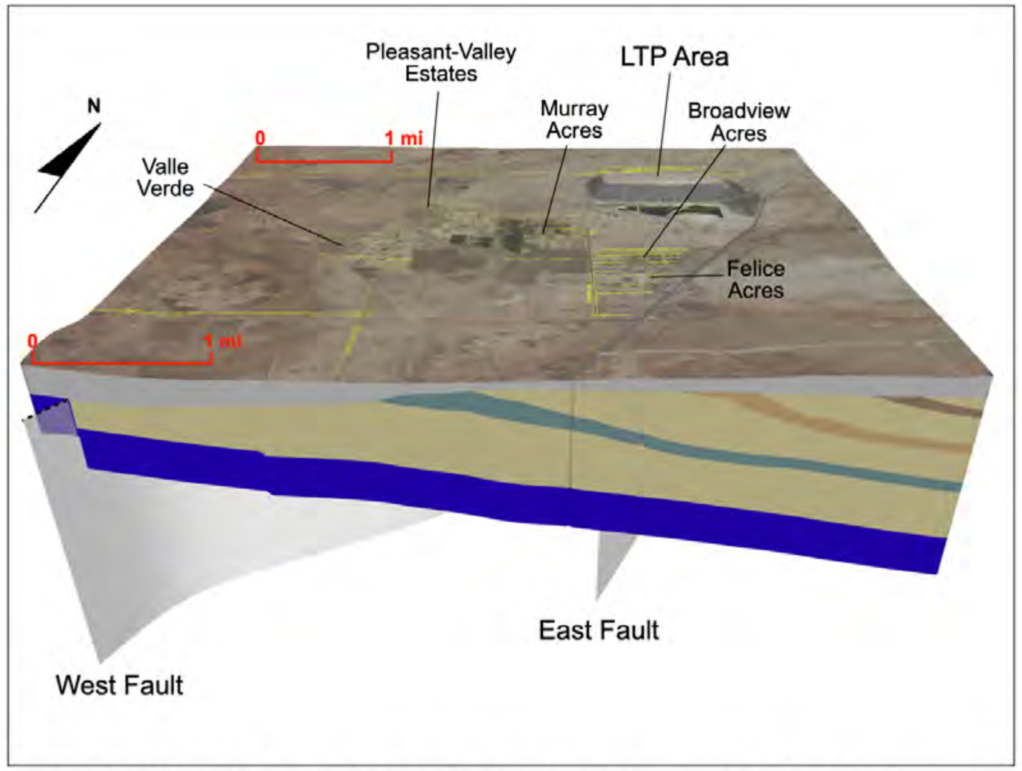
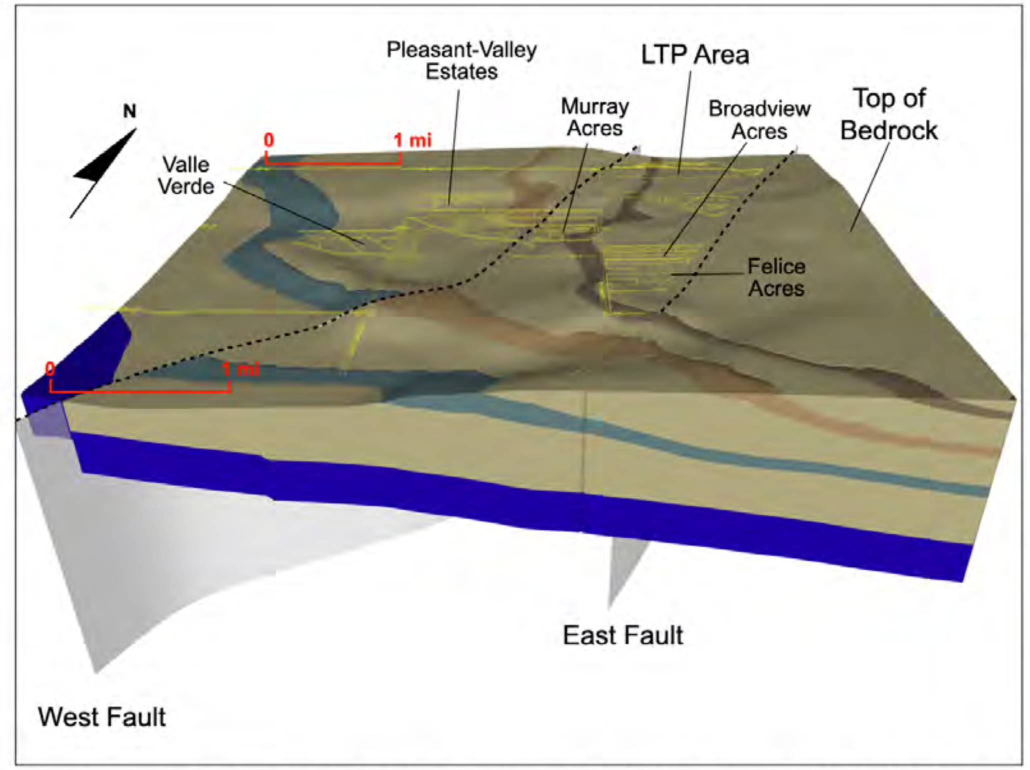
Corrective Action Program

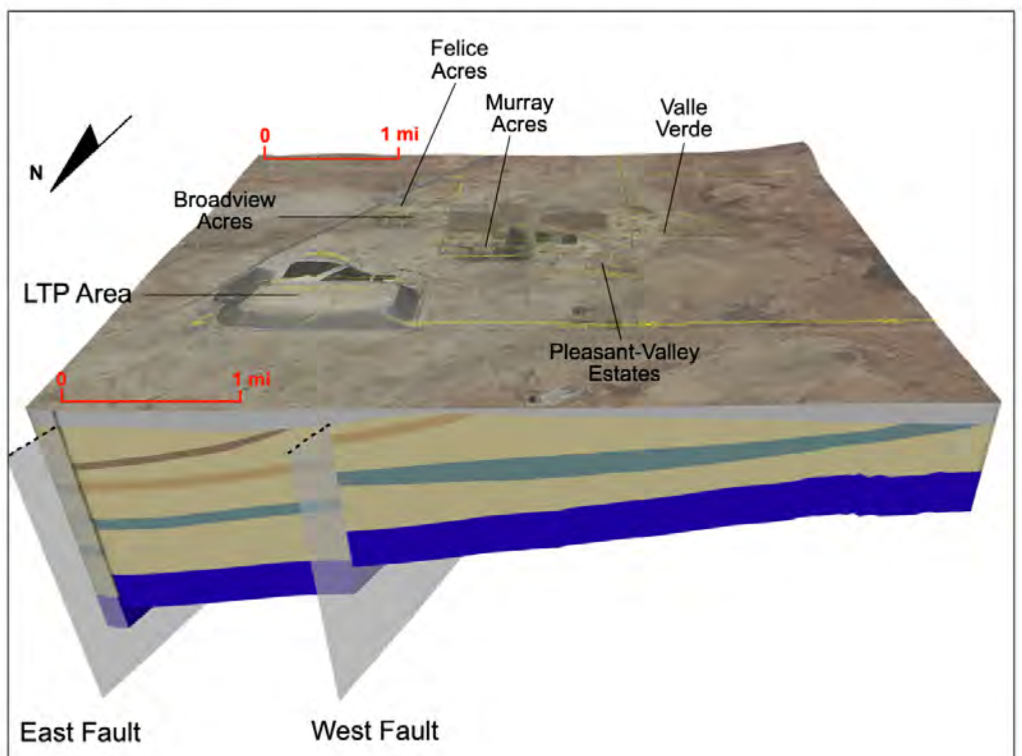
Figure 3-8
Faults Mapped at GRP



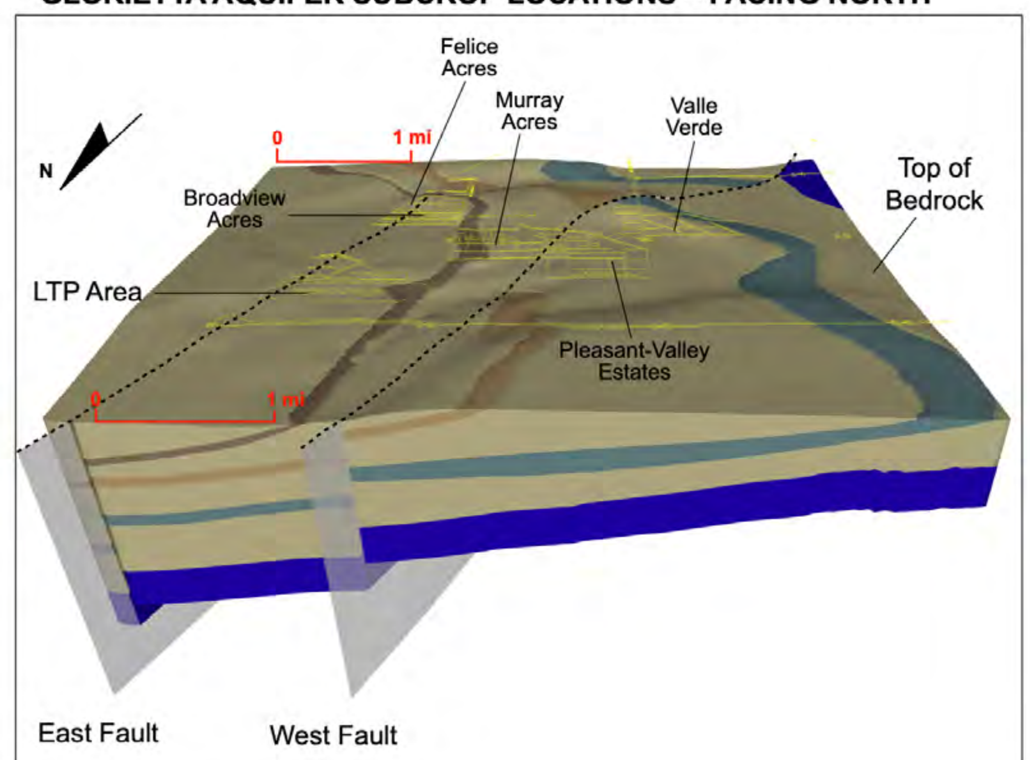
1. ALLUVIUM AND BEDROCK BLOCK MODEL – FACING NORTH



2. BEDROCK BLOCK MODEL DEPICTING CHINLE AND SAN ANDRES-GLORIETTA AQUIFER SUBCROP LOCATIONS – FACING NORTH



3. ALLUVIUM AND BEDROCK BLOCK MODEL – FACING SOUTH



4. BEDROCK BLOCK MODEL DEPICTING CHINLE AND SAN ANDRES-GLORIETTA AQUIFER SUBCROP LOCATIONS – FACING SOUTH

LEGENDS:

BEDROCK HYDROSTRATIGRAPHY

- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- CHINLE SHALE
- MIDDLE CHINLE AQUIFER
- CHINLE SHALE
- LOWER CHINLE AQUIFER
- CHINLE SHALE
- SAN ANDRES-GLORIETTA AQUIFER

NOTES:

1. 3D model output depicted at 5x vertical exaggeration.

Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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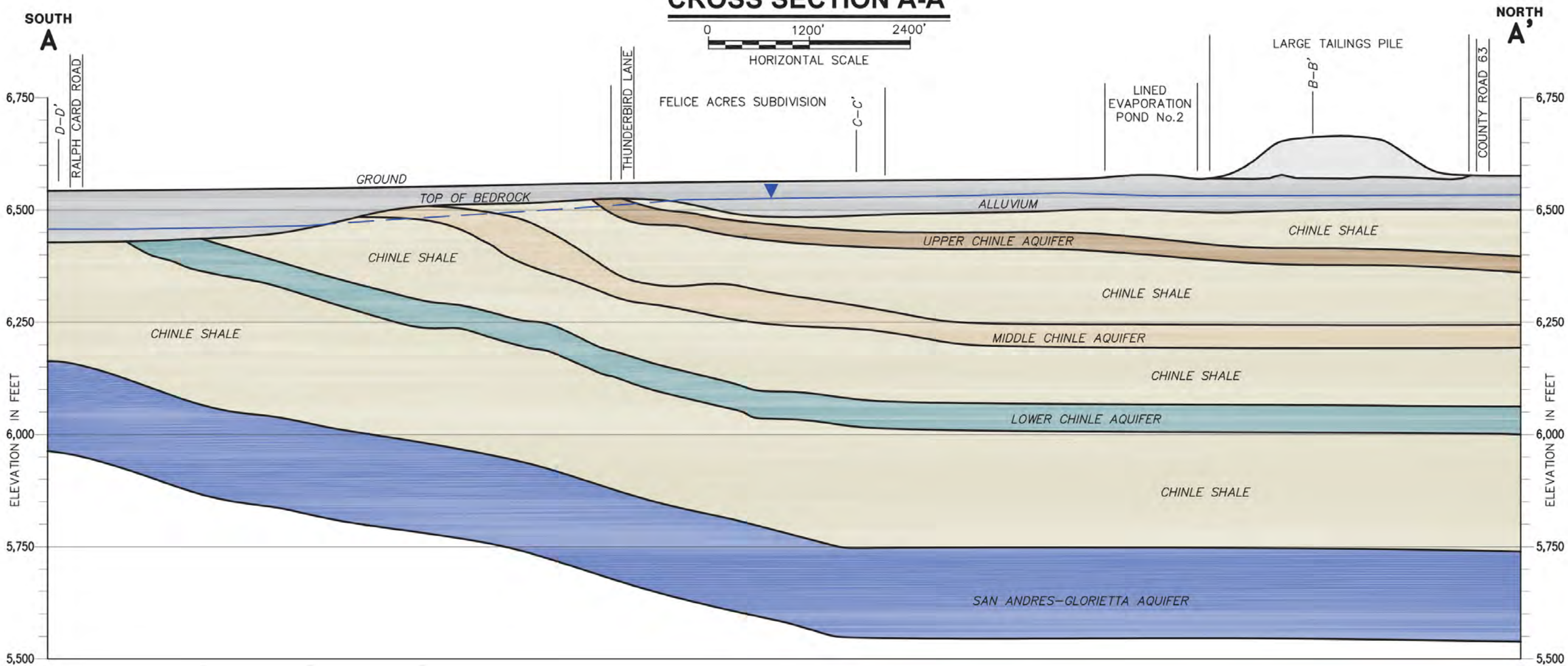
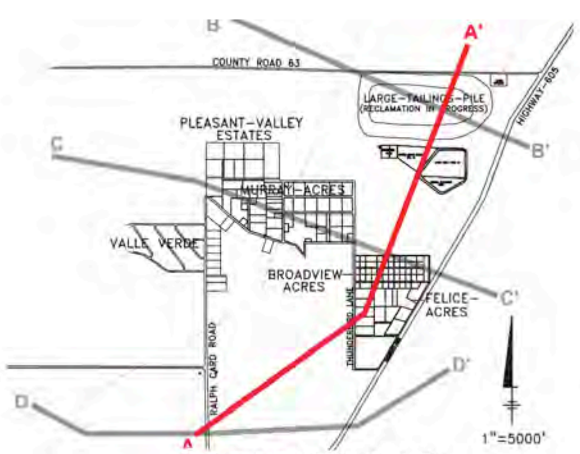
Grants Reclamation Project
Corrective Action Program

Figure 3-9
3D Hydrogeology

CROSS SECTION A-A'





LOCATION MAP

NOTE:

1. THREE–DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERTICAL EXAGGERATION.

LEGEND:

- LARGE TAILINGS PILE
- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES–GLORIETTA AQUIFER
- WATER TABLE

Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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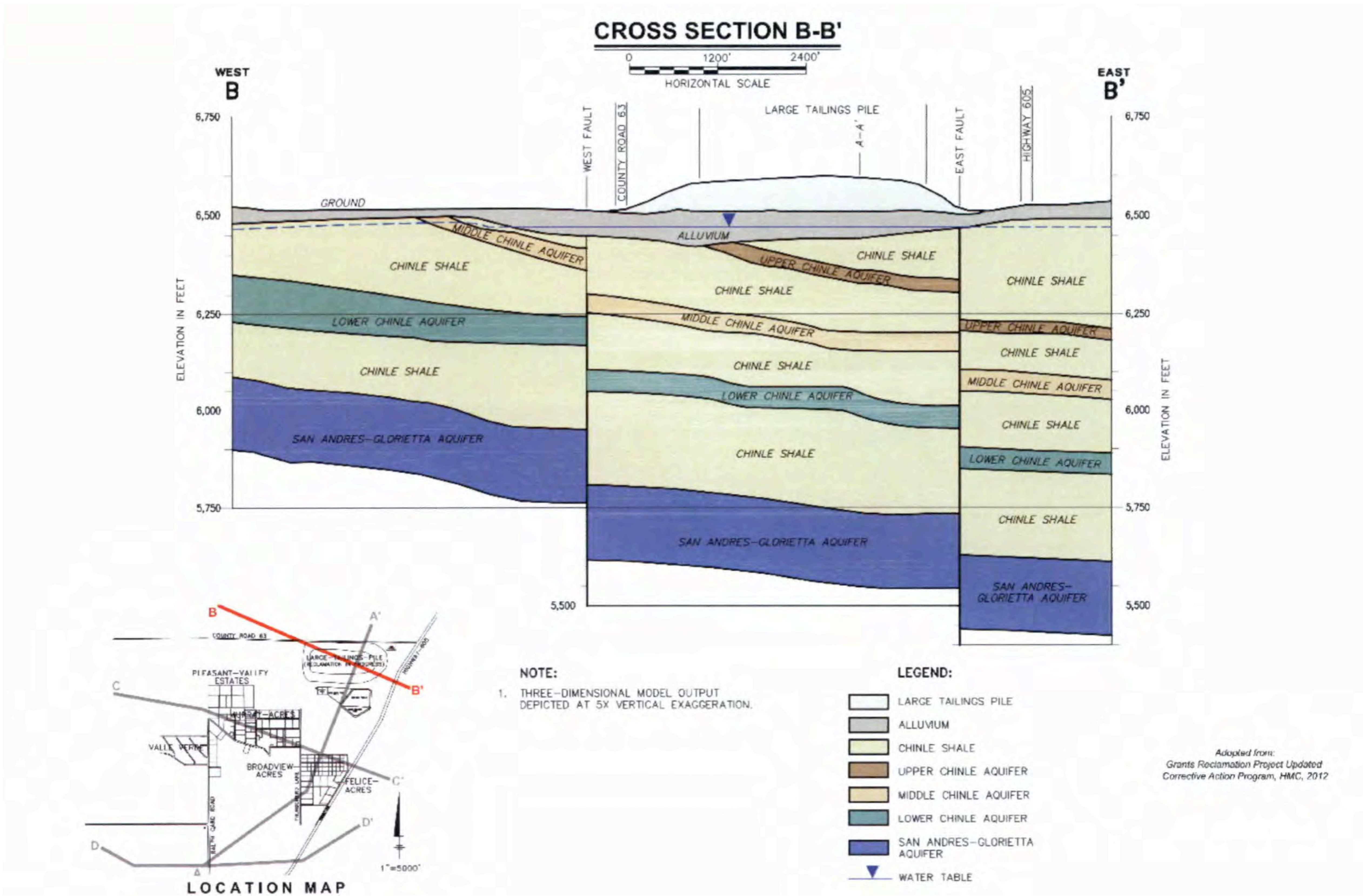
Corrective Action Program

Figure 3-10
Cross Section A-A'



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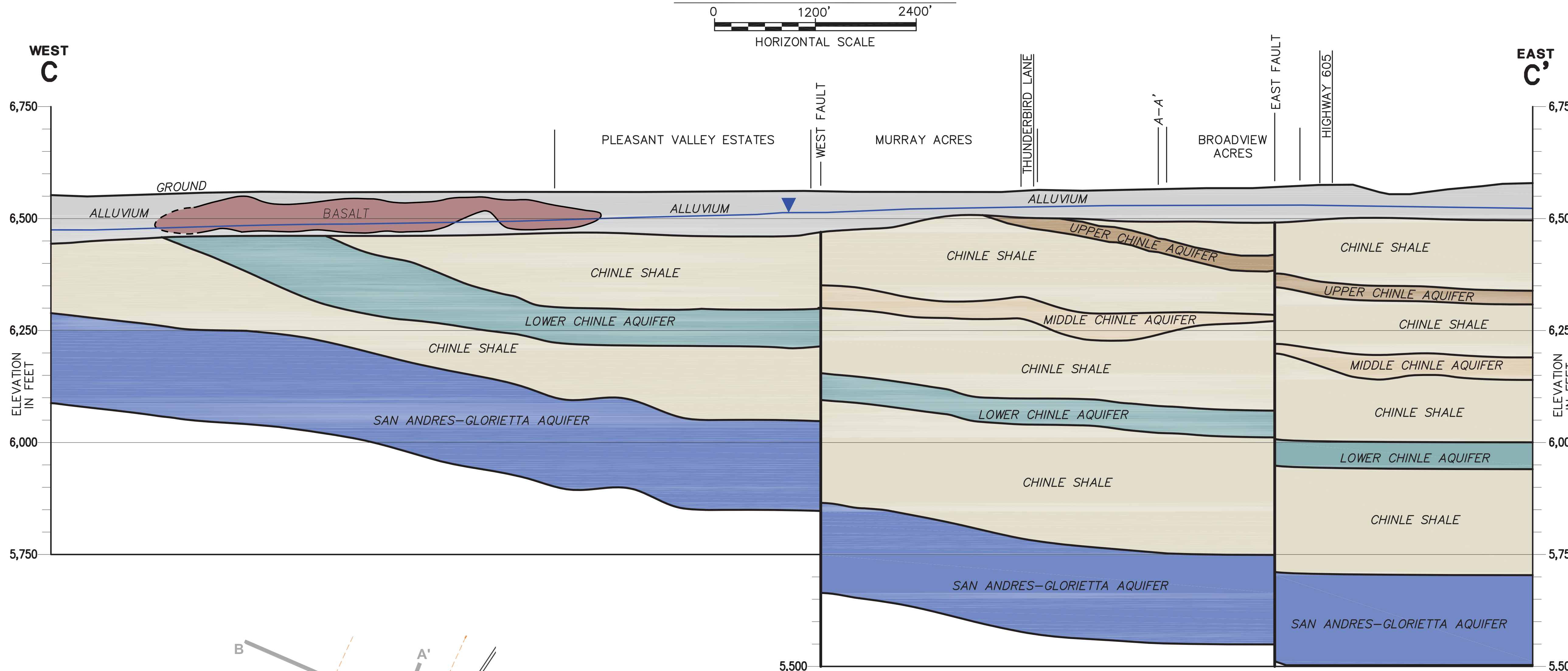
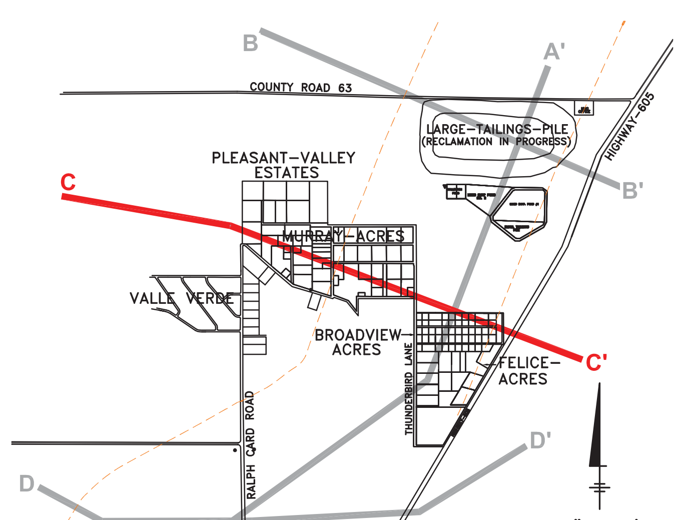
Corrective Action Program

Source: HDR, 2016

Figure 3-11
Cross Section B-B'

CROSS SECTION C-C'





LOCATION MAP

NOTES:

1. THREE-DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERITICAL EXAGGERATION.
2. GEOLOGIC CONTACTS DASHED WHERE INFERRED.

LEGEND:

- ALLUVIUM
- BASALT
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES-GLORIETTA AQUIFER
- WATER TABLE

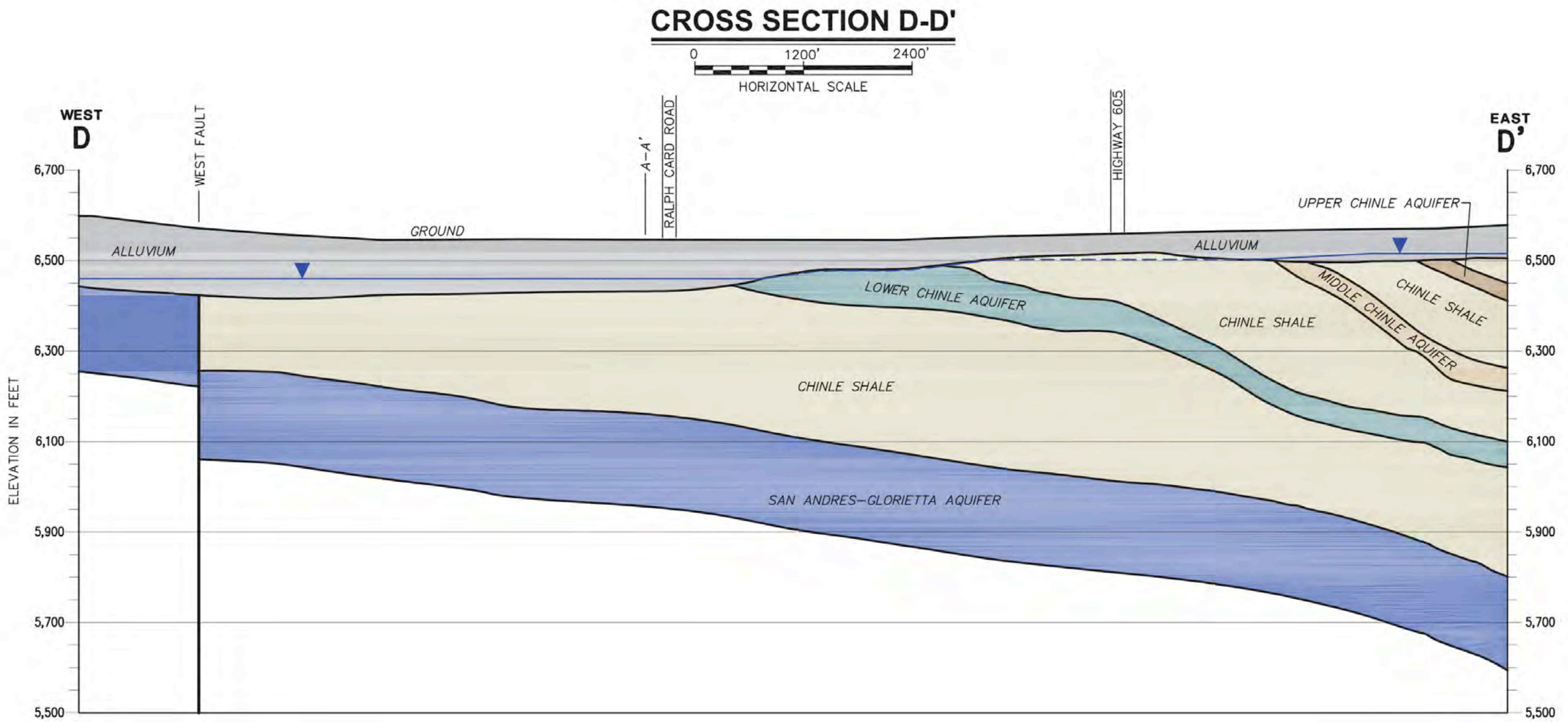
Modified: September 4, 2015
Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

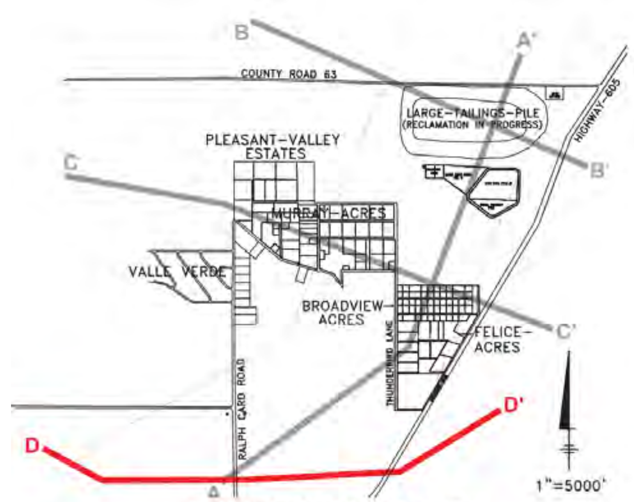
HOMESTAKE
Grants Reclamation Project
Corrective Action Program

Source: HDR, 2016

Figure 3-12
Cross Section C-C'

CROSS SECTION D-D'





LOCATION MAP

NOTE:

1. THREE–DIMENSIONAL MODEL OUTPUT DEPICTED AT 5X VERTICAL EXAGGERATION.

LEGEND:

- LARGE TAILINGS PILE
- ALLUVIUM
- CHINLE SHALE
- UPPER CHINLE AQUIFER
- MIDDLE CHINLE AQUIFER
- LOWER CHINLE AQUIFER
- SAN ANDRES–GLORIETTA AQUIFER
- WATER TABLE

Adopted from:
Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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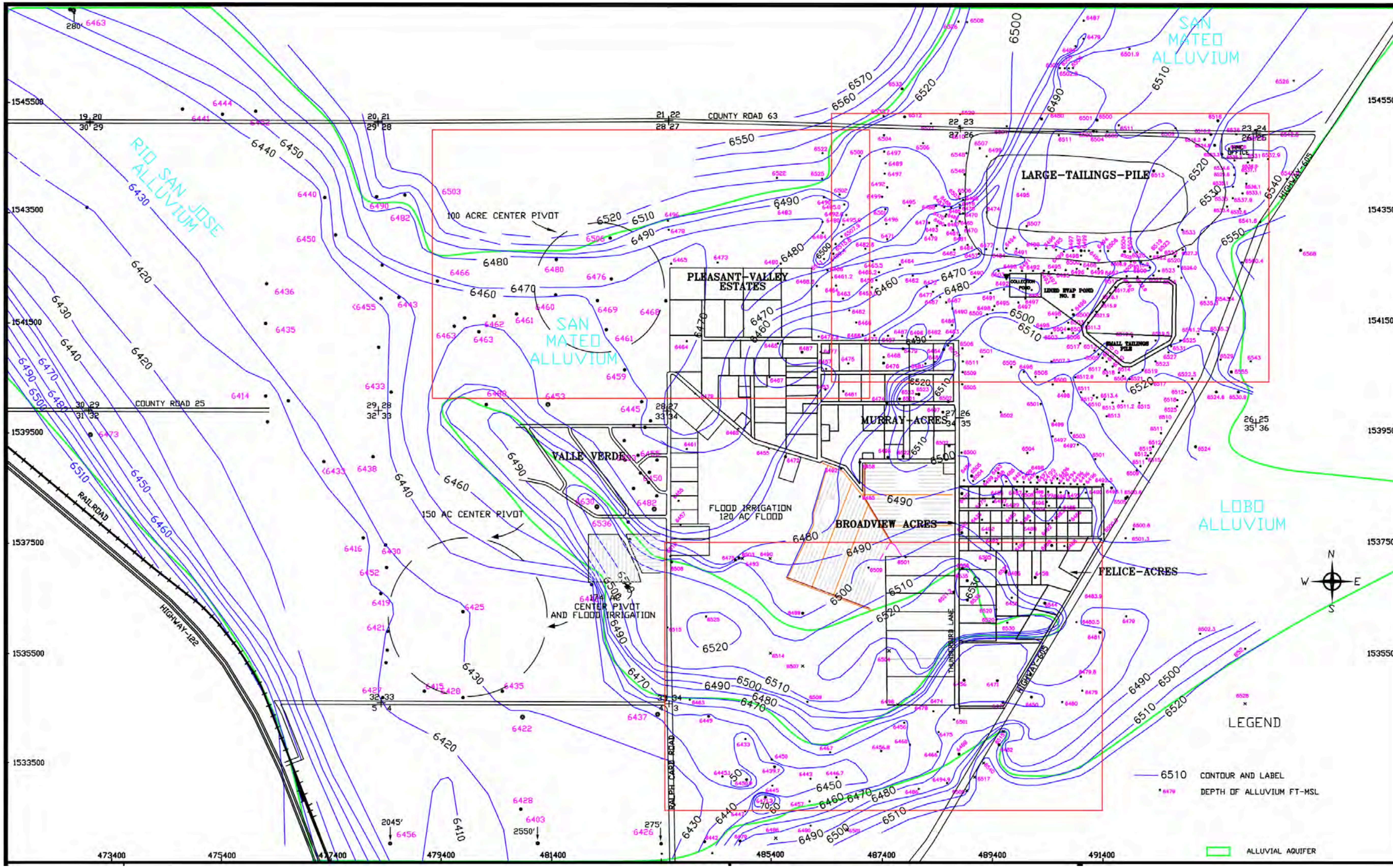
Grants Reclamation Project
Corrective Action Program

Figure 3-13
Cross Section D-D'

Grants Reclamation Project
Corrective Action Program

Figure 3-14
Alluvial Well Locations



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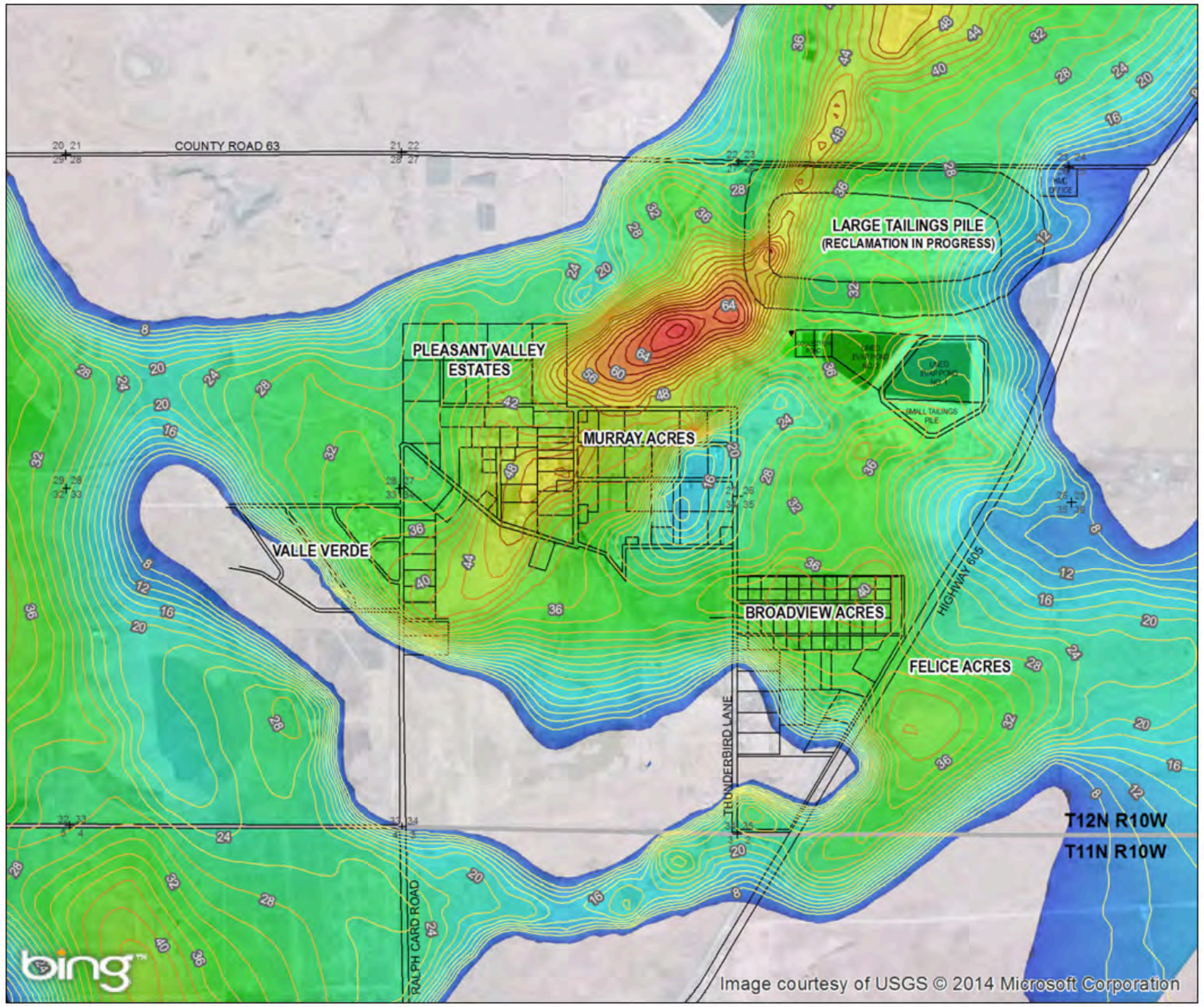
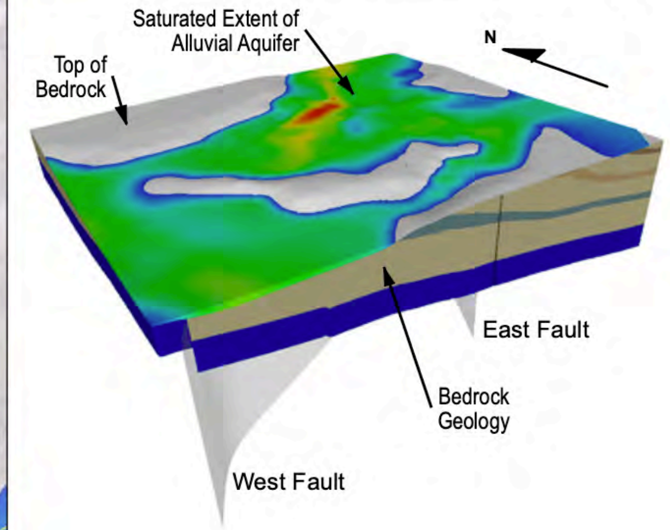
Grants Reclamation Project
Corrective Action Program

Elevation-feet above mean sea level

Figure 3-15
Elevation of Base of The Alluvium



3D BEDROCK GEOLOGY AND SATURATED EXTENT OF ALLUVIAL AQUIFER - FACING NORTHEAST



LEGENDS:

Saturated Alluvial Thickness (feet)

69
60
52
43
34
26
17
9
0

Bedrock Hydrostratigraphy

- Chinle Shale
- Upper Chinle Aquifer
- Chinle Shale
- Middle Chinle Aquifer
- Chinle Shale
- Lower Chinle Aquifer
- Chinle Shale
- San Andres-Glorietta Aquifer

Source: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

N

0 1,350 2,700 Feet

Aerial: Bing Maps - © 2010 Microsoft Corporation and its data suppliers

Thickness Contours in Feet

- 8 - 16
- 17 - 26
- 27 - 36
- 37 - 46
- 47 - 56
- 57 - 68

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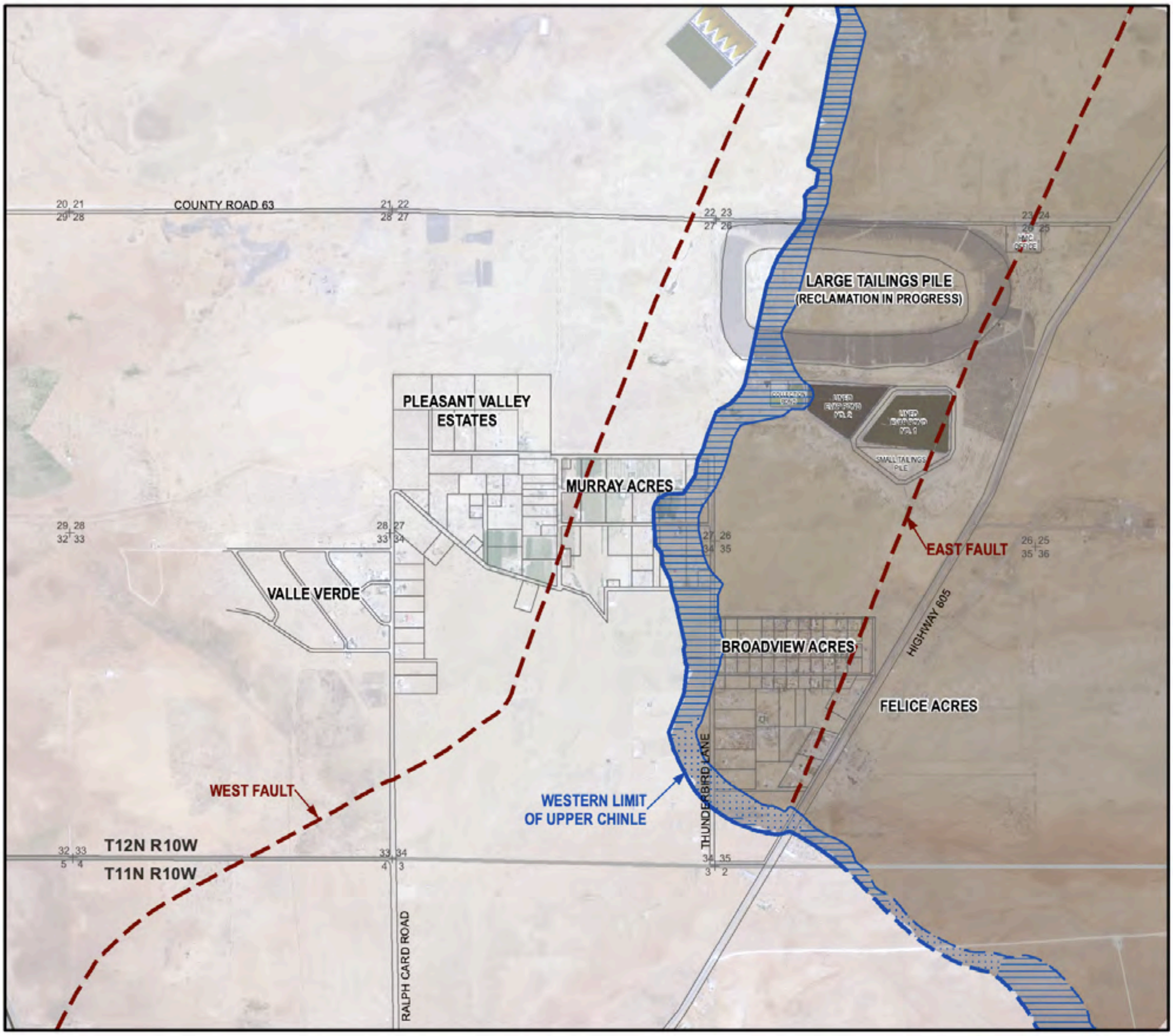
Corrective Action Program

Figure 3-16
Saturated Extent of Alluvial Aquifer



LEGEND:

Fault

Subcrop of Upper Chinle Alluvium Overlies Sandstone

(Subcrop boundary dashed where inferred)

Saturated Alluvium

Unsaturated Alluvium

Extent of Upper Chinle Aquifer with Elevation Contour (ft-amsl)

N

0 1,250 2,500 Feet

Aerial Source: NAIP 2011
Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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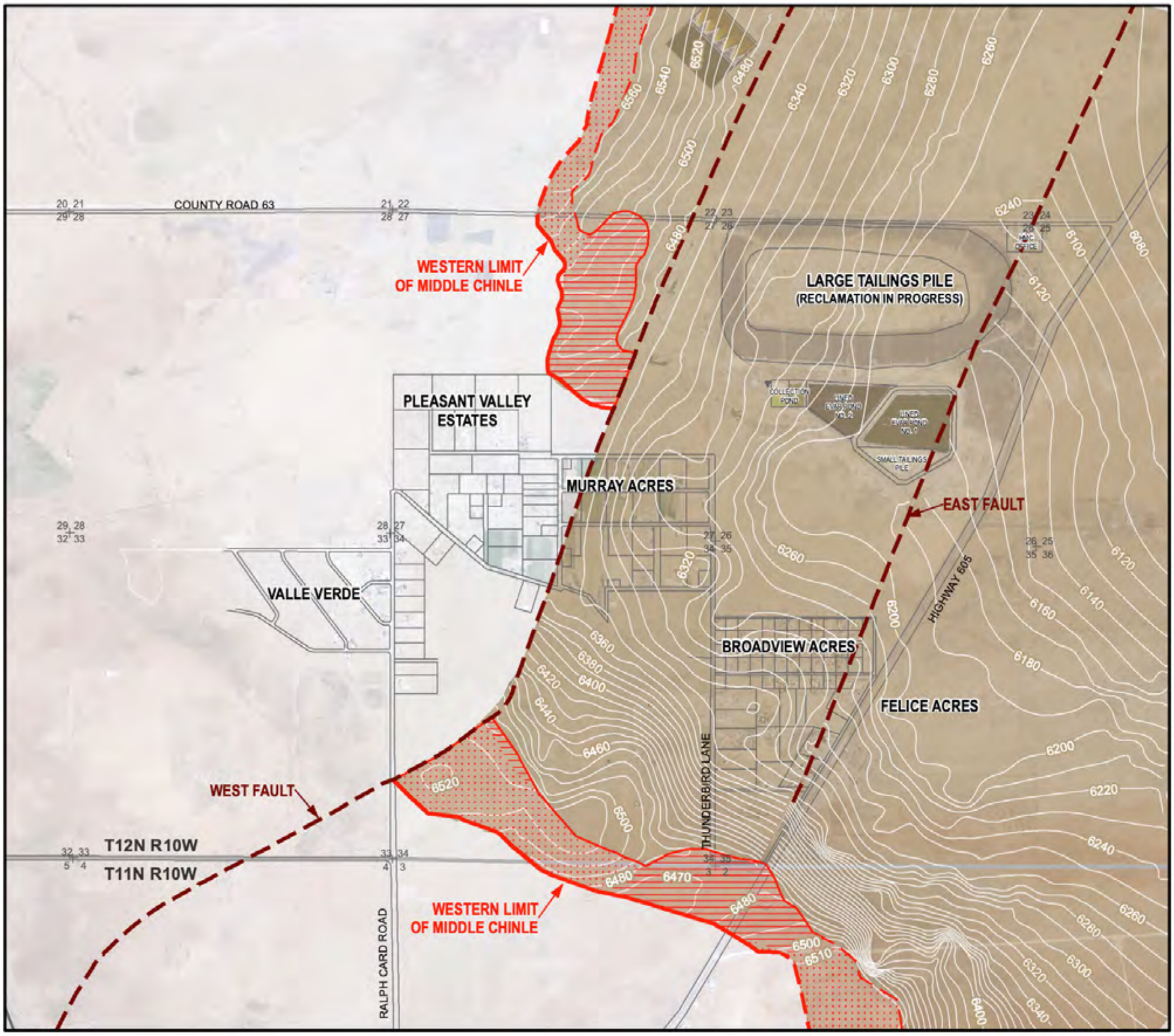
Corrective Action Program

Figure 3-17
Extent of the Upper Chinle



LEGEND:

Fault

Subcrop of Middle Chinle Alluvium Overlies Sandstone
(Subcrop boundary dashed where inferred)

Saturated Alluvium

Unsaturated Alluvium

Extent of Middle Chinle Aquifer with Elevation Contour (ft-amsl)

N

0 1,250 2,500 Feet

Aerial Source: NAIP 2011
Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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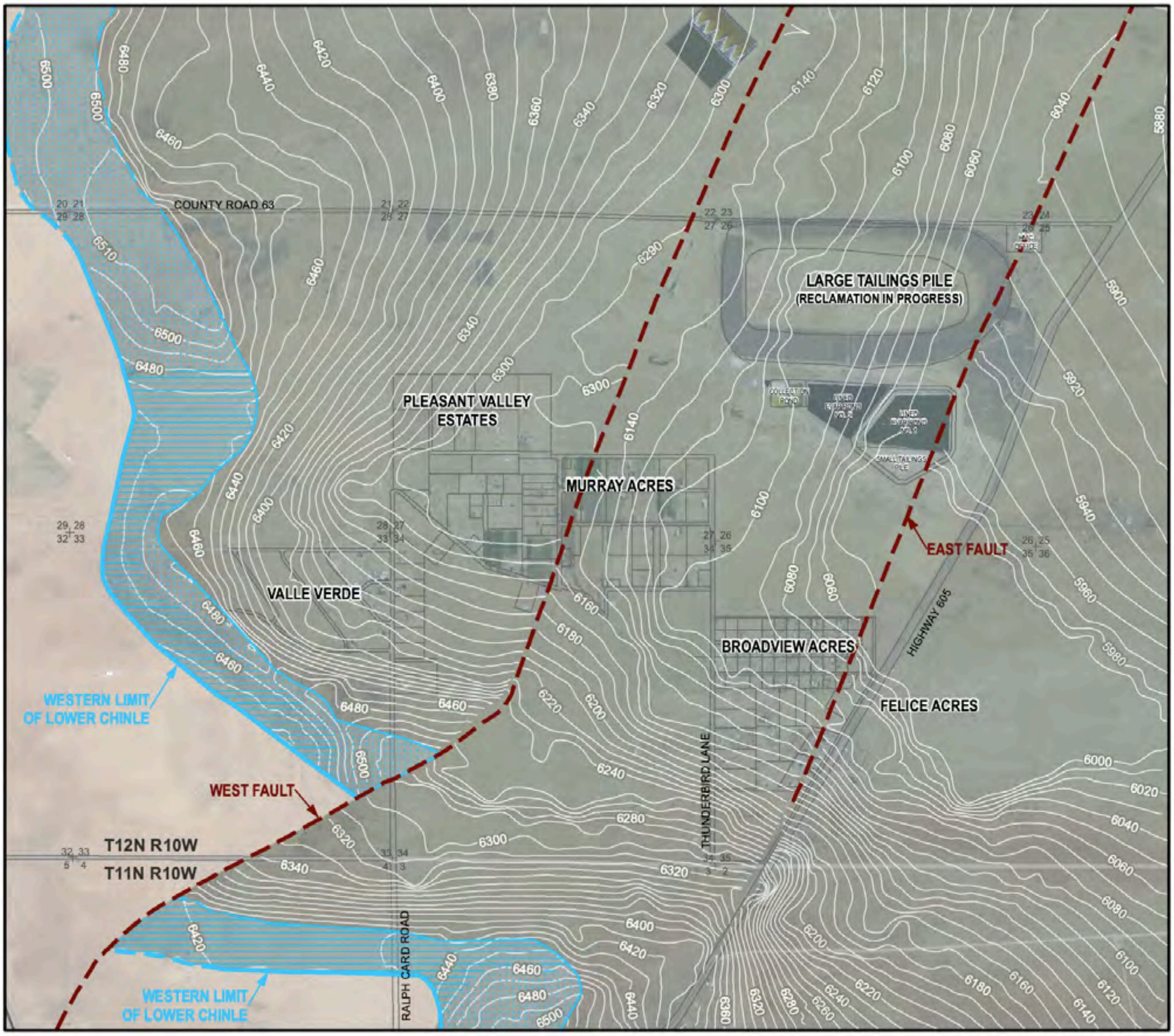
Corrective Action Program

Figure 3-18
Extent of the Middle Chinle



LEGEND:

Fault

Subcrop of Lower Chinle
Alluvium Overlies Secondary Porosity
(Subcrop boundary dashed where inferred)

Saturated Alluvium

Unsaturated Alluvium

Extent of Lower Chinle Aquifer with Elevation Contour (ft-amsl)

N

0 1,250 2,500 Feet

Aerial Source: NAIP 2011

Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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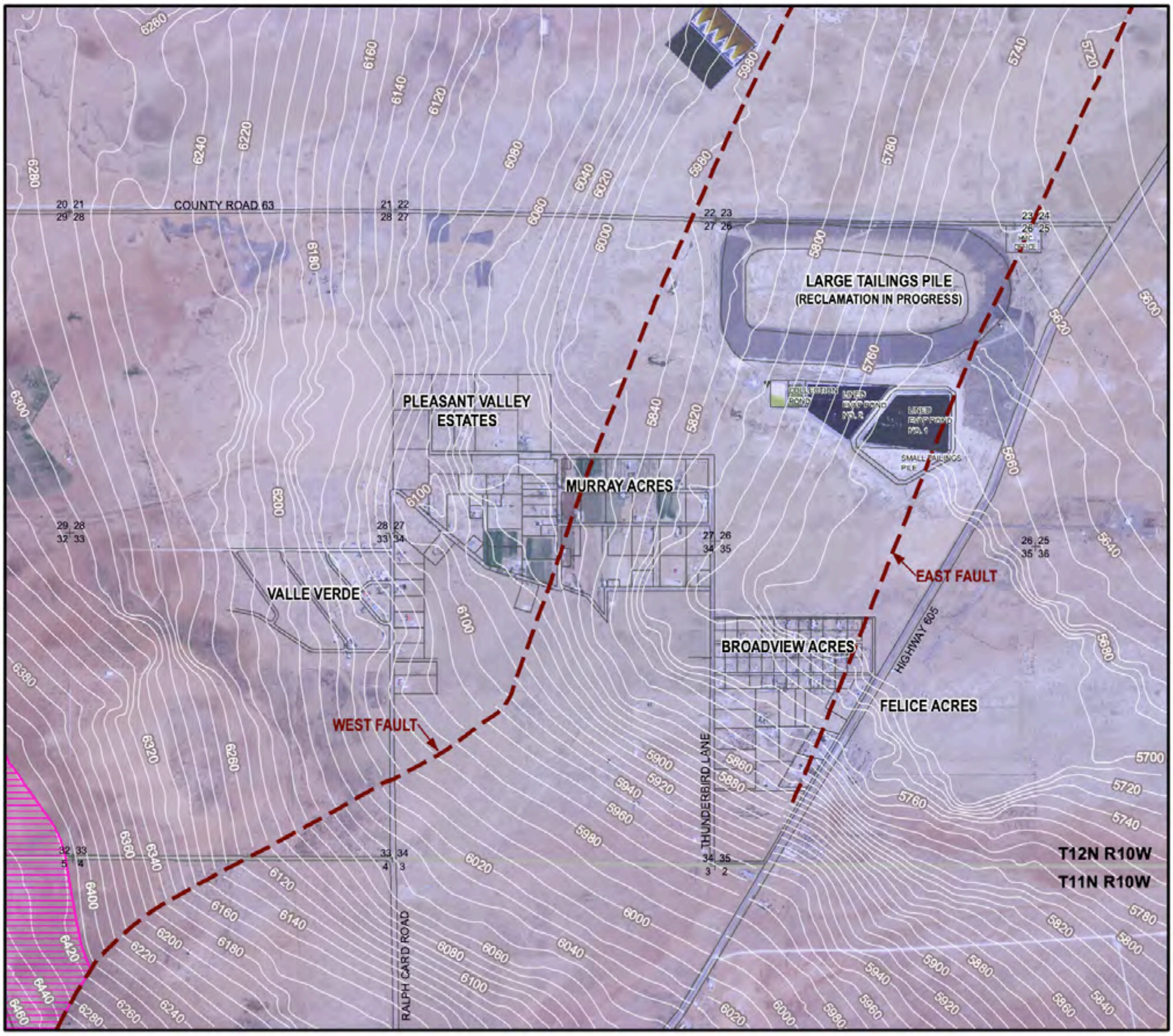
Corrective Action Program

Figure 3-19
Extent of the Lower Chinle



LEGEND:

Fault

Subcrop of San Andres-Glorietta
Alluvium Overlies Limestone

Saturated Alluvium

Extent of San Andres-Glorietta Aquifer with Elevation Contour (ft-amsl)

N

0 1,250 2,500 Feet

Aerial Source: NAIP 2011
Adopted from: Grants Reclamation Project Updated Corrective Action Program, HMC, 2012

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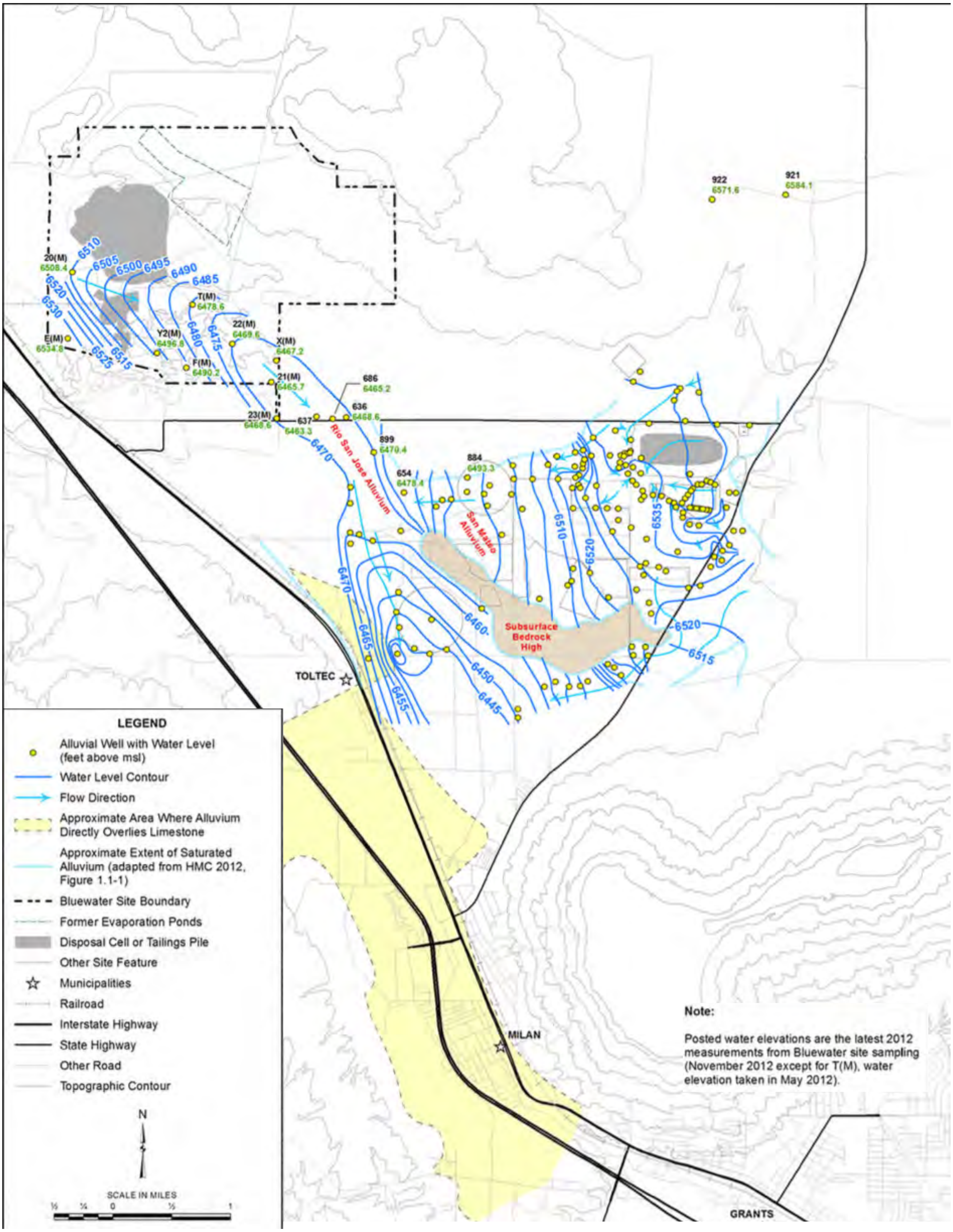
Grants Reclamation Project
Corrective Action Program

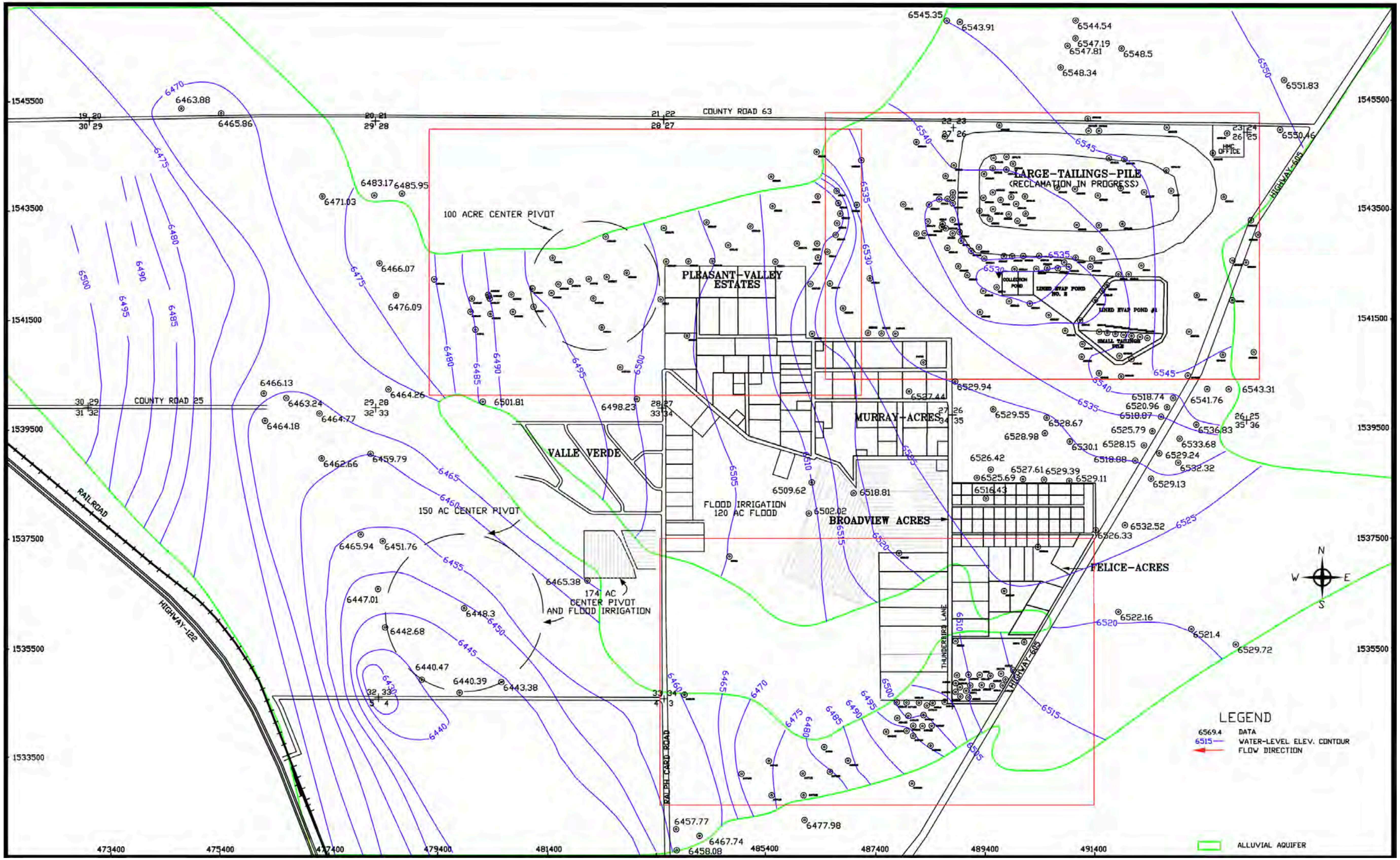
Figure 3-20
Extent San Andres Limestone and Glorieta Sandstone



Source: DOE, 2014

Grants Reclamation Project
Corrective Action Program

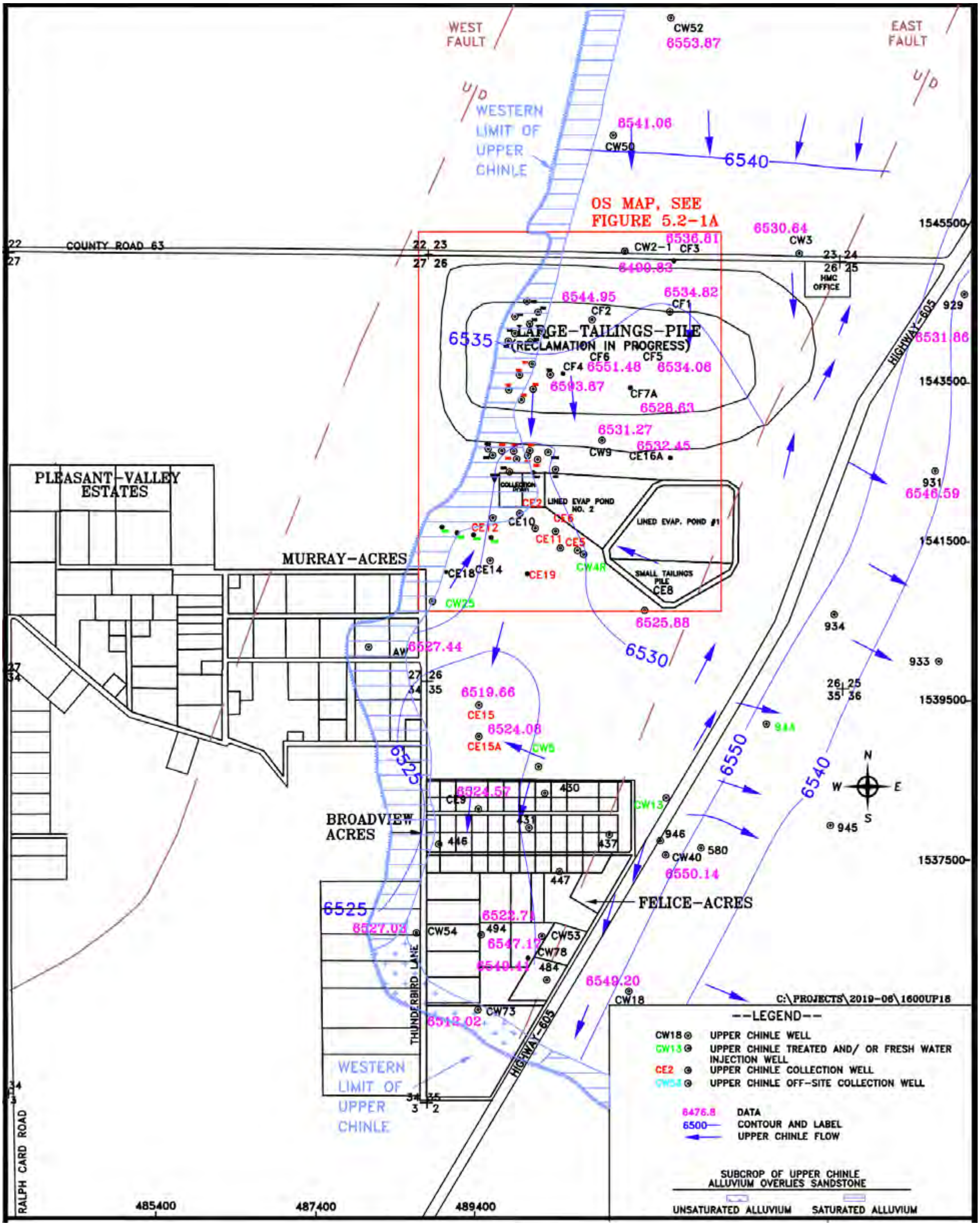
Figure 3-21
Alluvial Aquifer Regional Potentiometric Surface, 2012



Grants Reclamation Project
Corrective Action Program

Elevation-feet above mean sea level

Figure 3-22
Groundwater Potentiometric Surface
Alluvial Aquifer, Fall 2018



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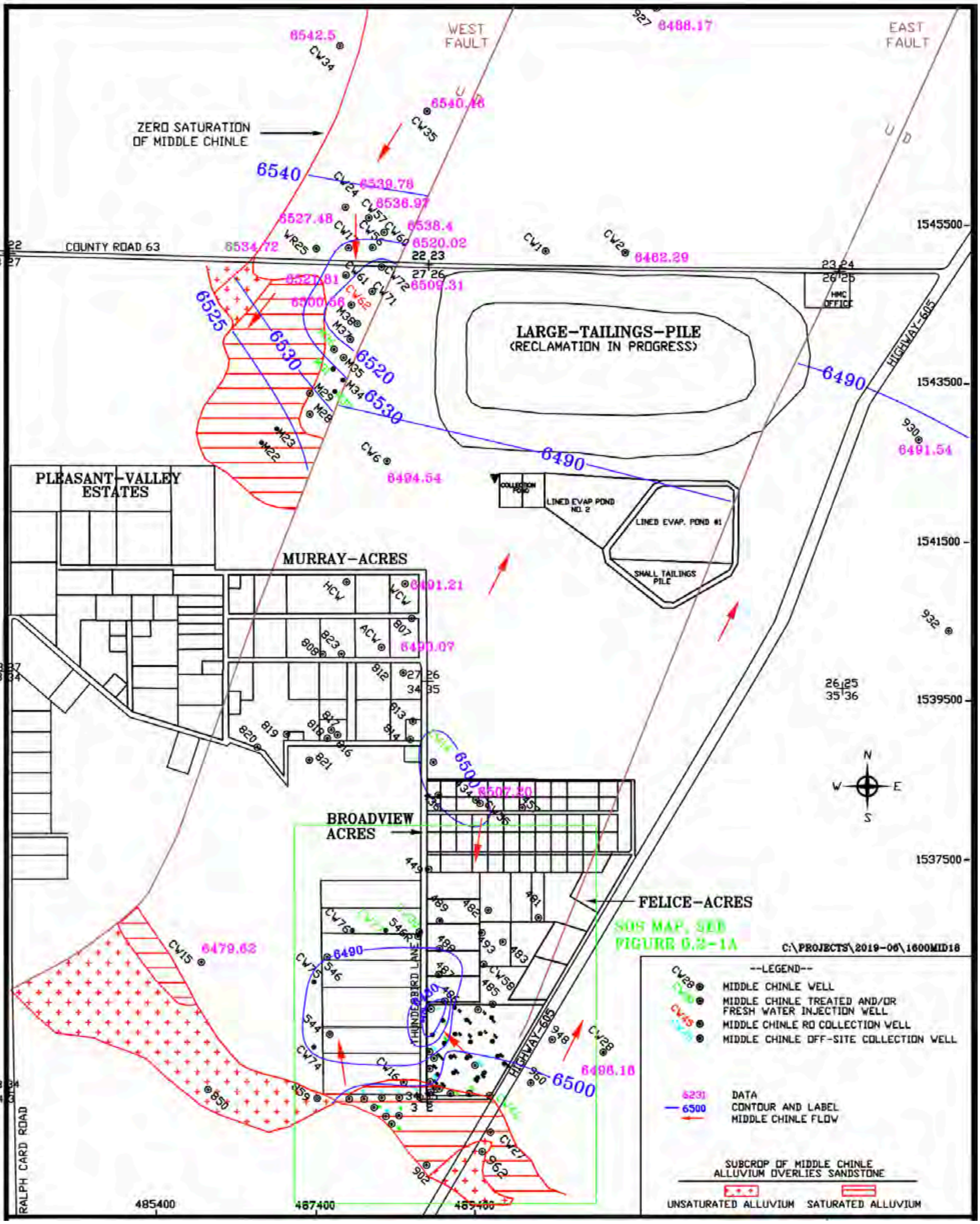
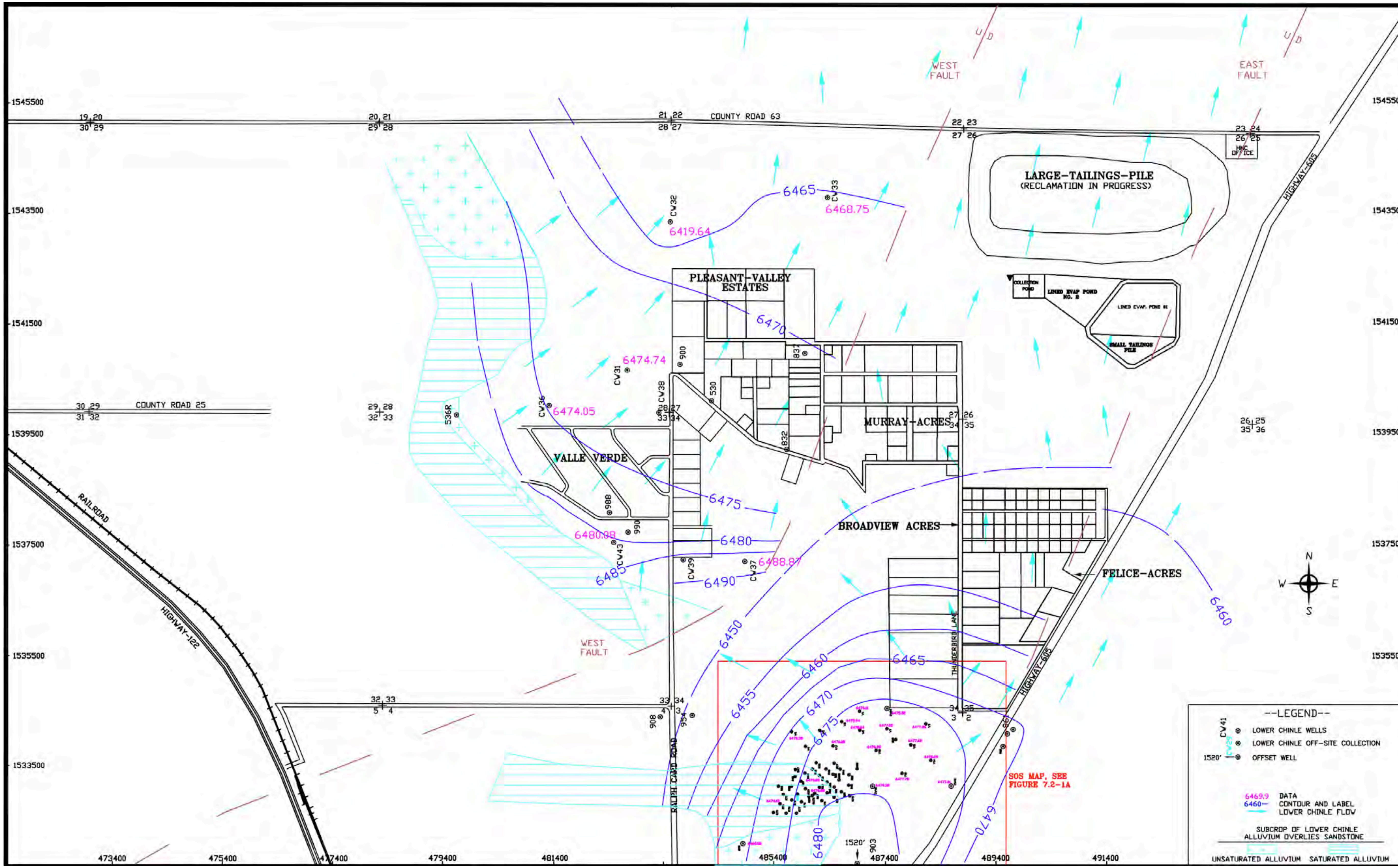
Corrective Action Program

Figure 3-23
Groundwater Potentiometric Surface
Upper Chinle Aquifer, Fall 2018



Grants Reclamation Project
Corrective Action Program

Figure 3-24
Groundwater Potentiometric Surface
Middle Chinle Aquifer, Fall 2018



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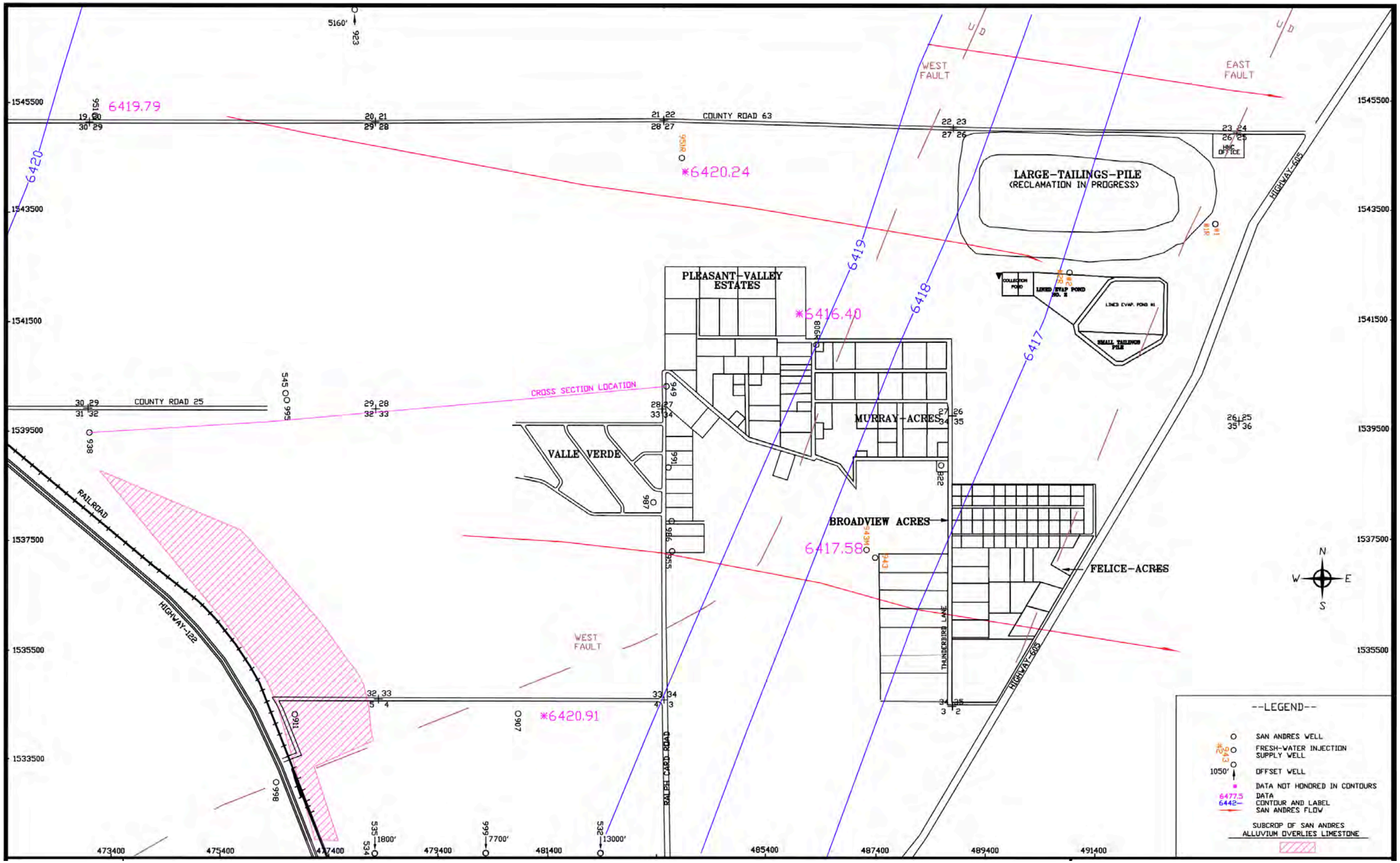
Corrective Action Program

Elevation-feet above mean sea level

Figure 3-25

Groundwater Potentiometric Surface

Lower Chinle Aquifer, 2018



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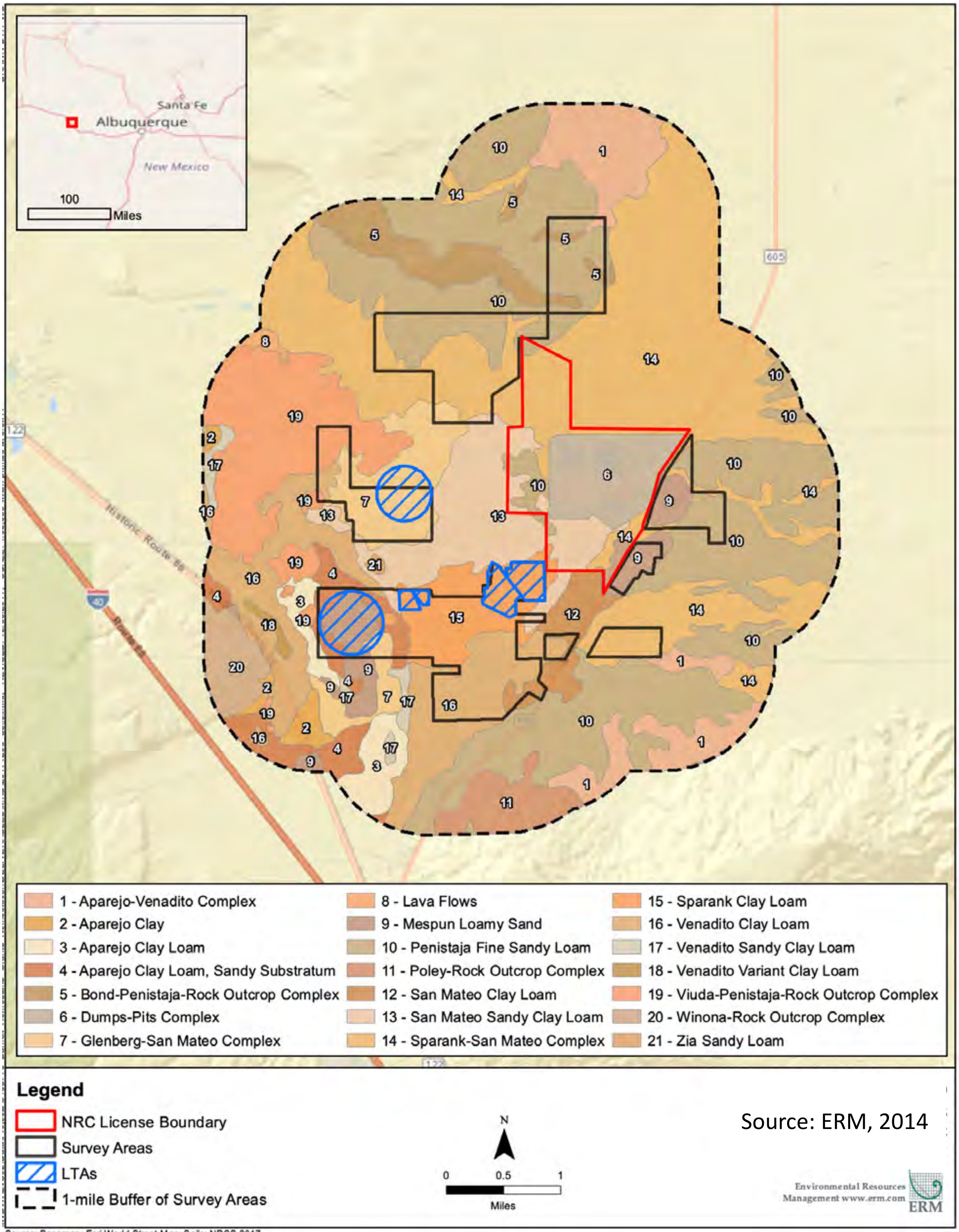
Corrective Action Program

Elevation-feet above mean sea level

Figure 3-26
Groundwater Potentiometric Surface
San Andres Aquifer, 2018



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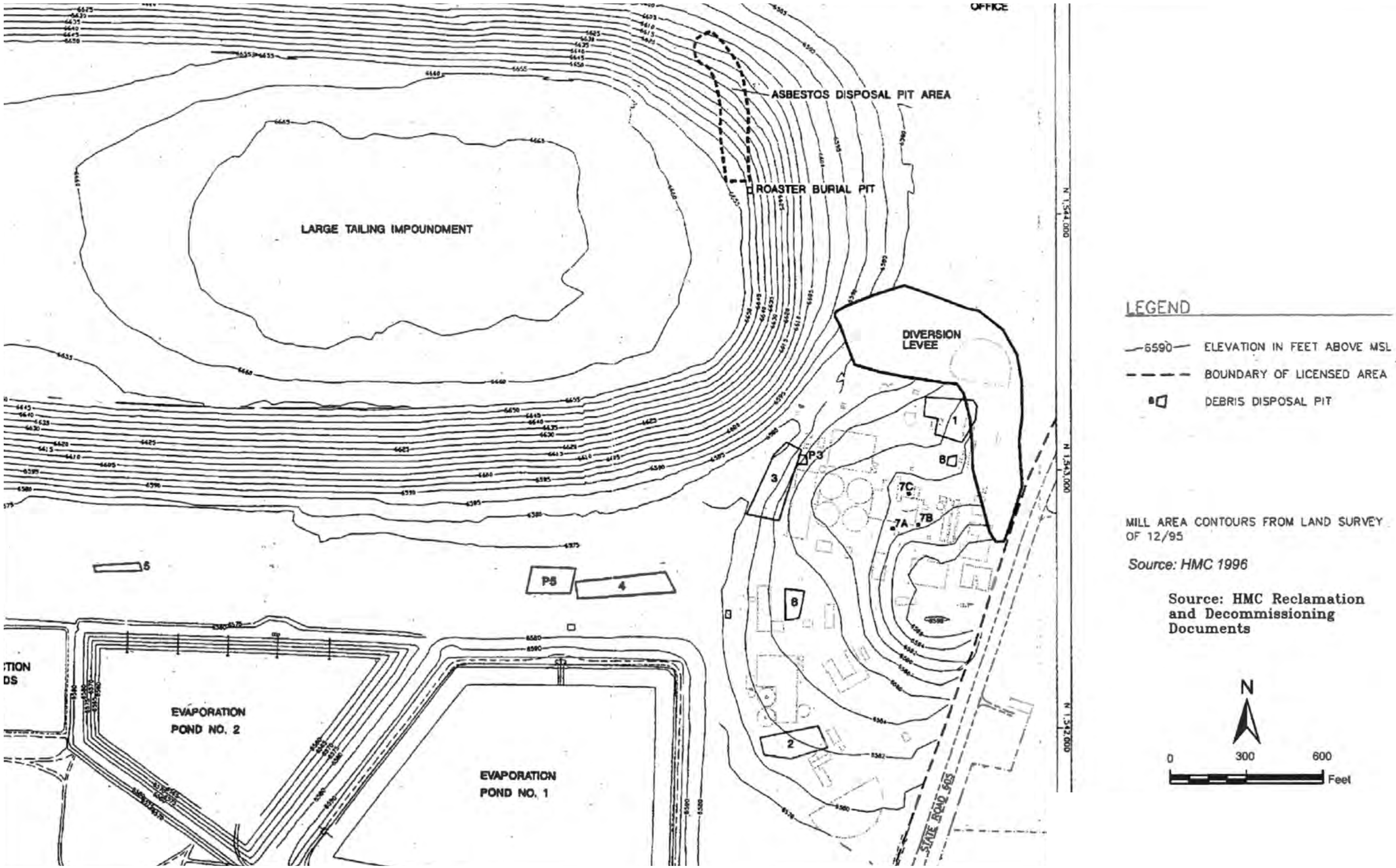
Grants Reclamation Project
Corrective Action Program

Figure 3-27
NRCS Soil Map

Grants Reclamation Project
Corrective Action Program

Source: HDR, 2016

Figure 3-28
GRP Constructed Site Features



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Corrective Action Program

Figure 3-29
GRP Diversion Levee

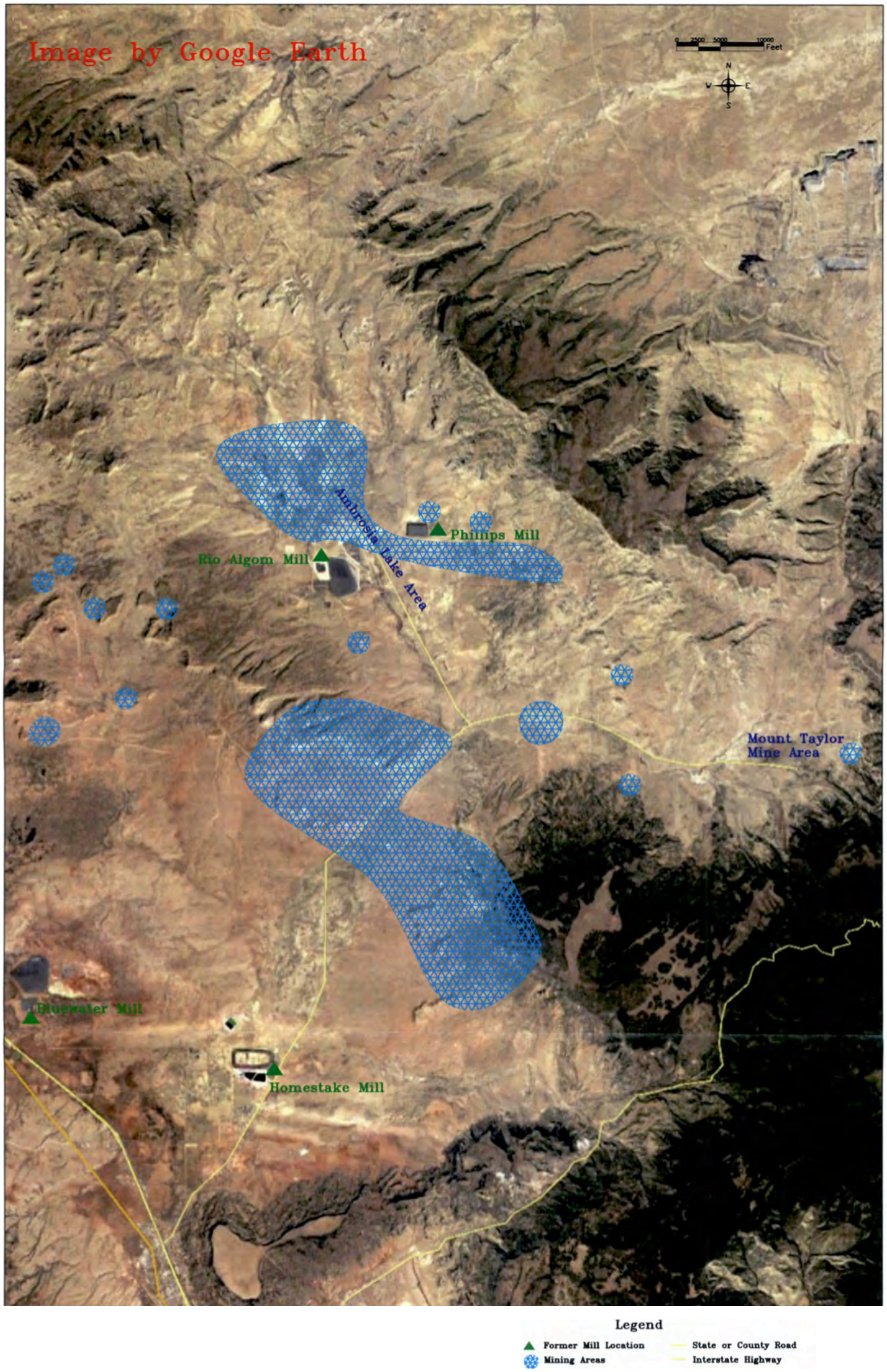

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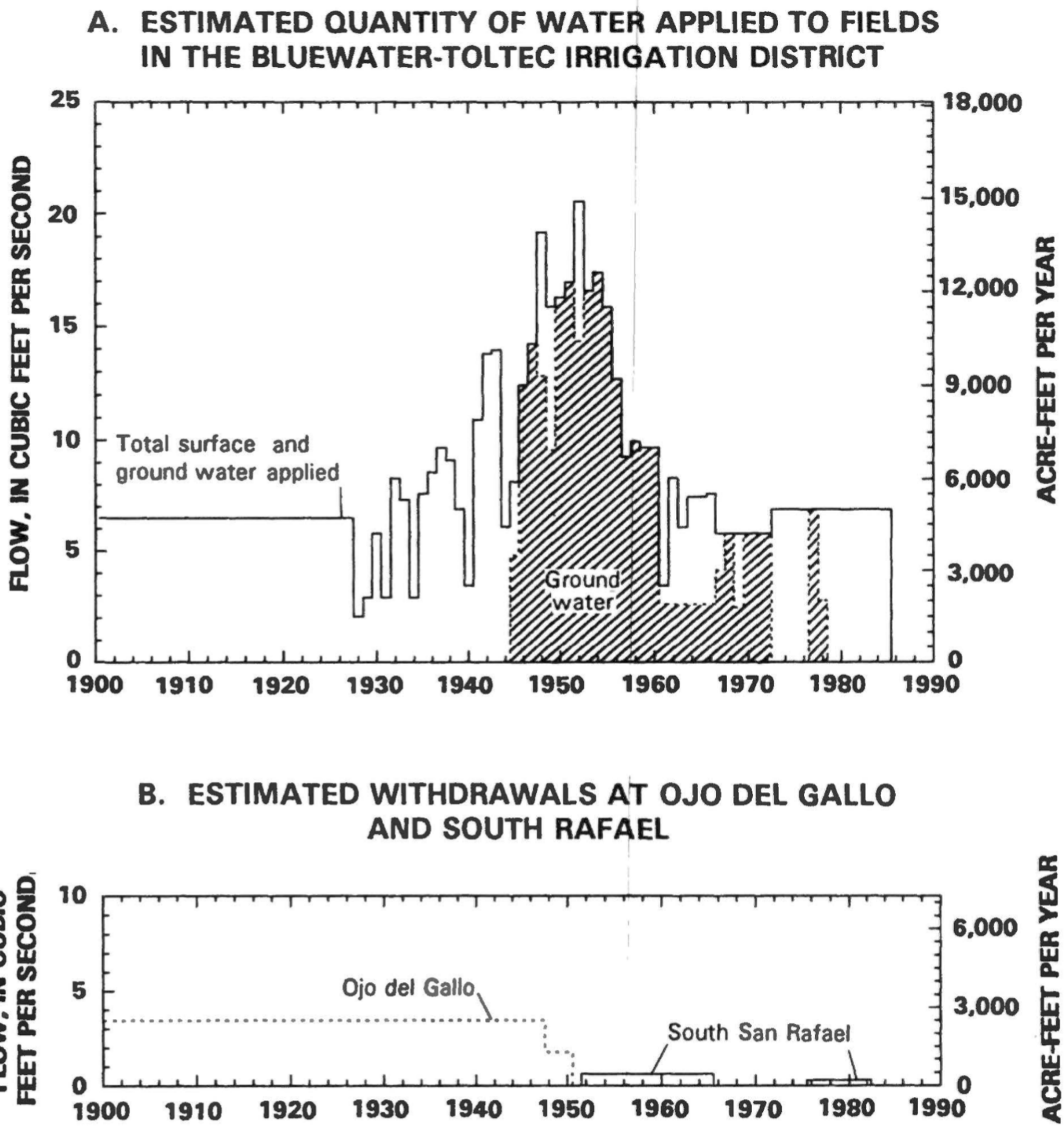
Figure 3-30
San Mateo Basin Mining Areas



Source: Frenzel, 1992

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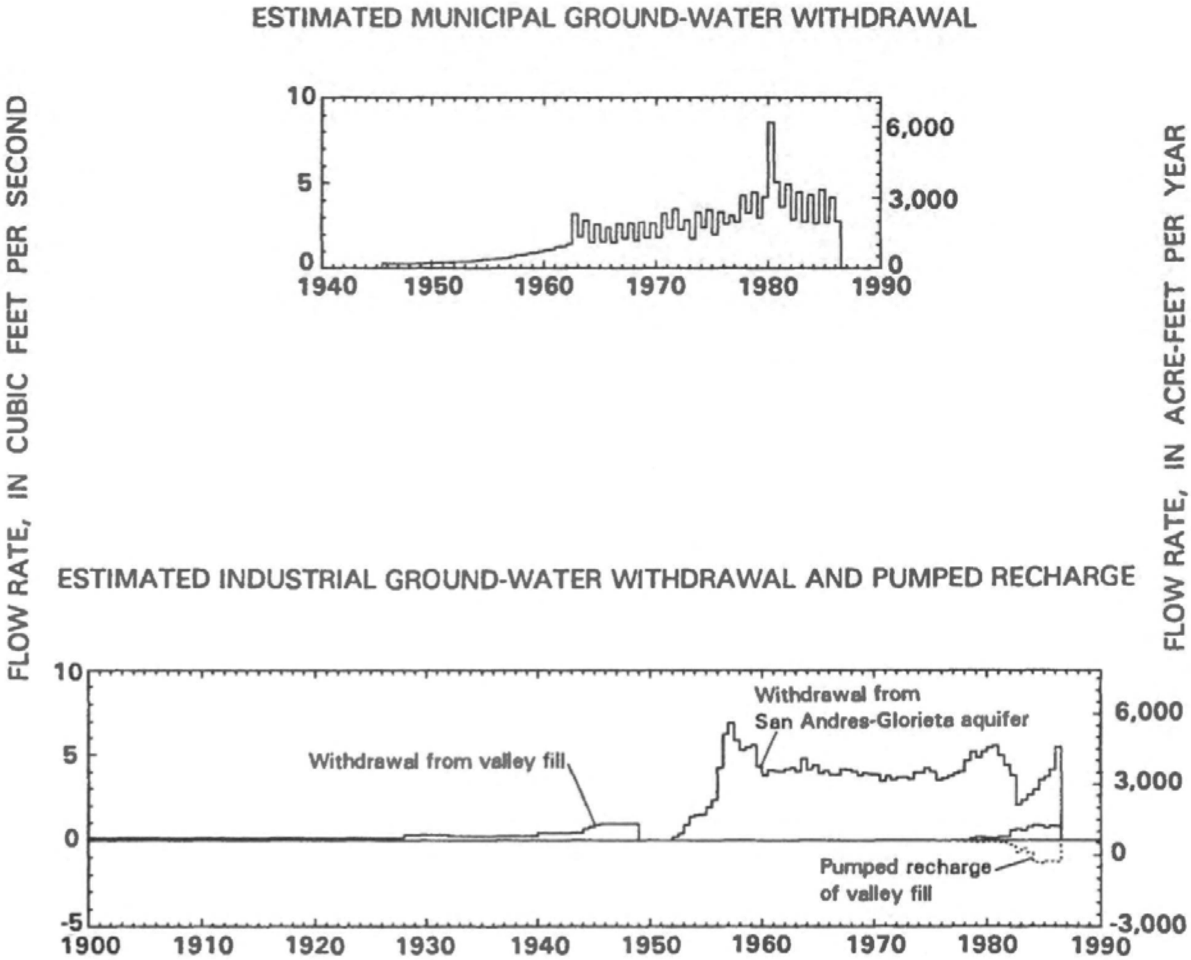
Corrective Action Program

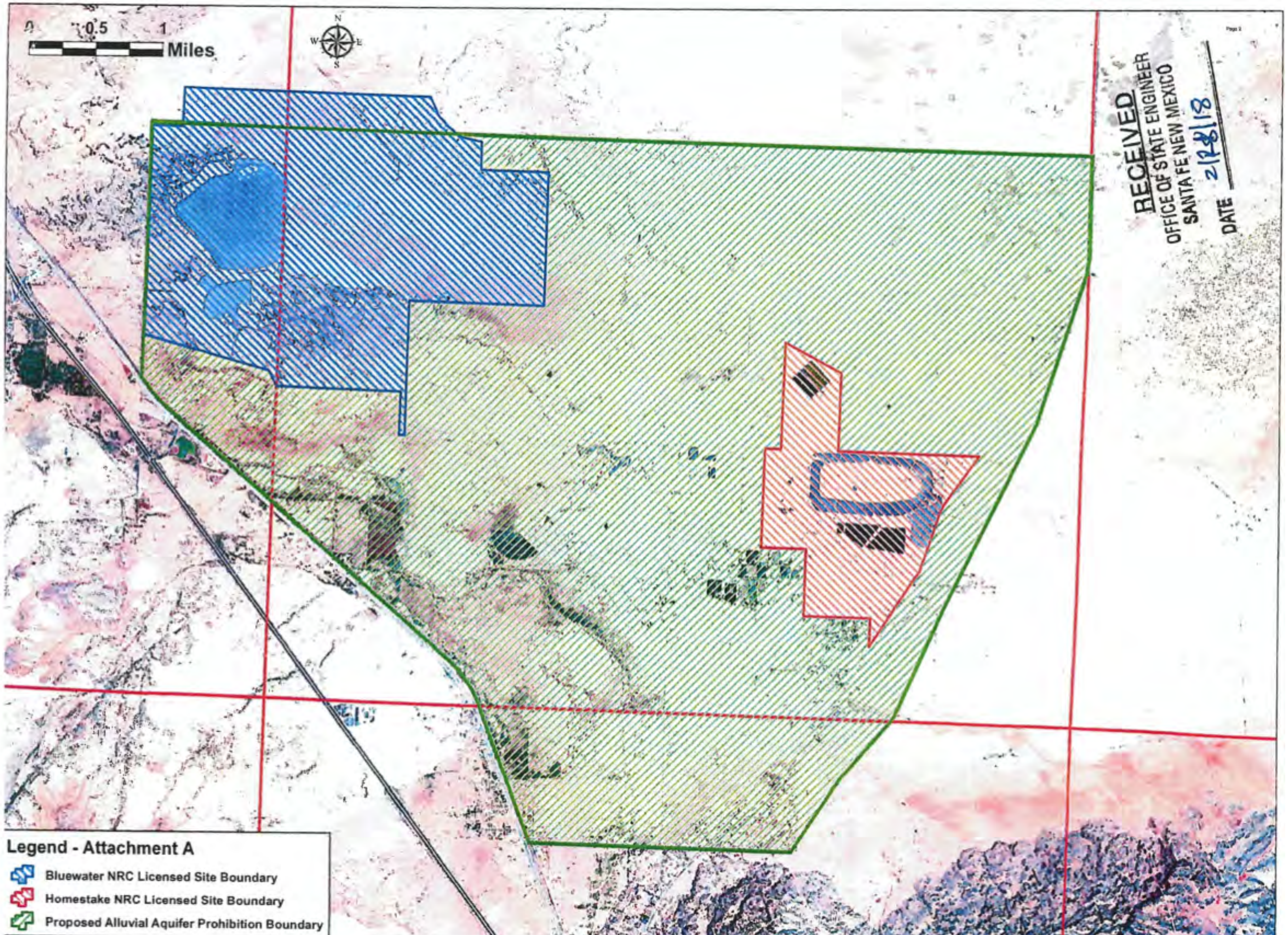
Figure 3-31
Estimated Irrigation Pumping in the San Andres Limestone and Glorieta Sandstone Aquifer



Source: Frenzel, 1992

Grants Reclamation Project
Corrective Action Program

Figure 3-32
Estimated Municipal and Industrial Pumping in the San Andres Limestone and Glorieta Sandstone Aquifer



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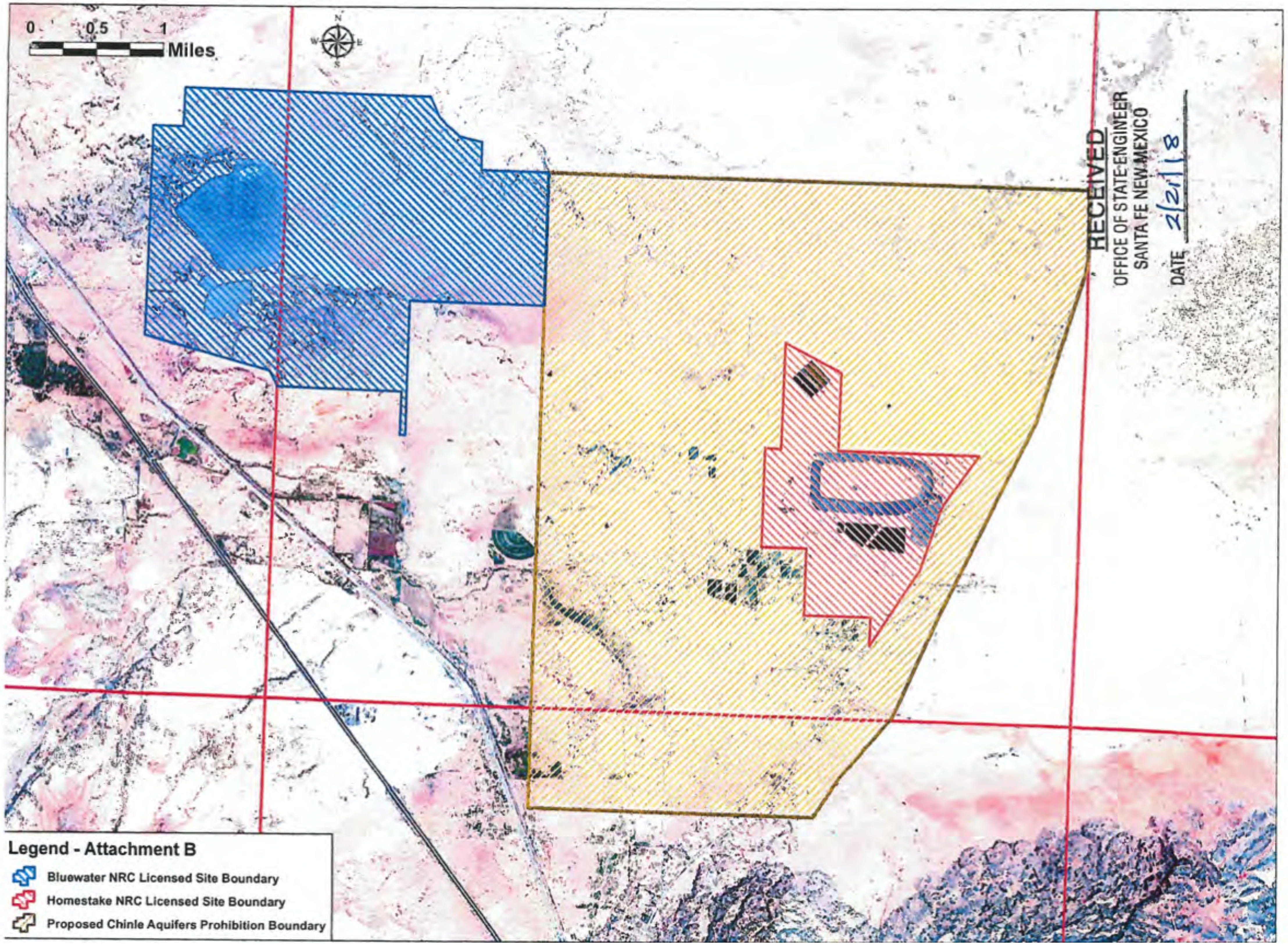
Corrective Action Program

Source: NMSEO, 2018

Figure 3-33
Alluvial Aquifer Prohibition Boundary



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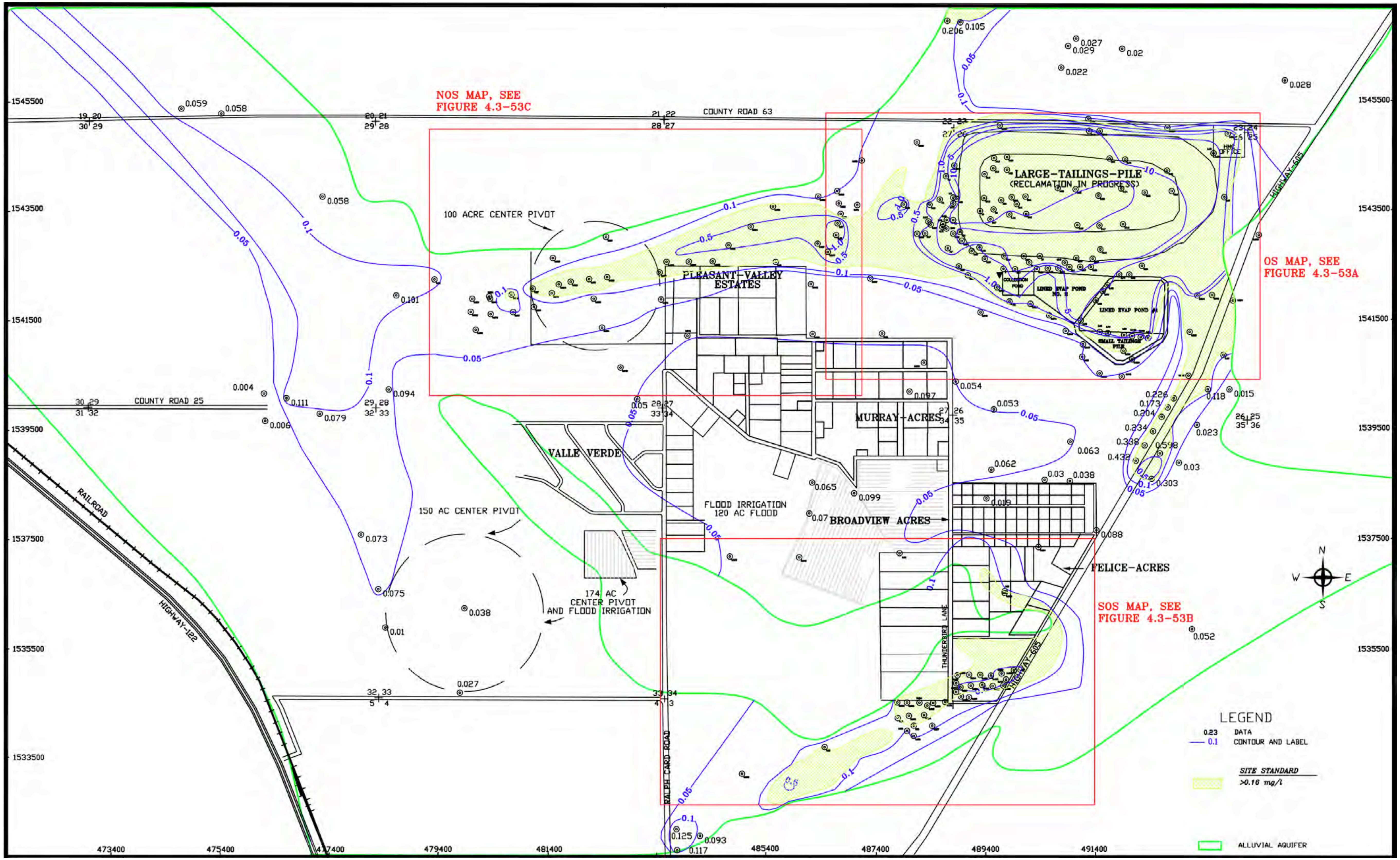
Grants Reclamation Project
Corrective Action Program

Source: NMSEO, 2018

Figure 3-34
Chinle Aquifers Prohibition Boundary



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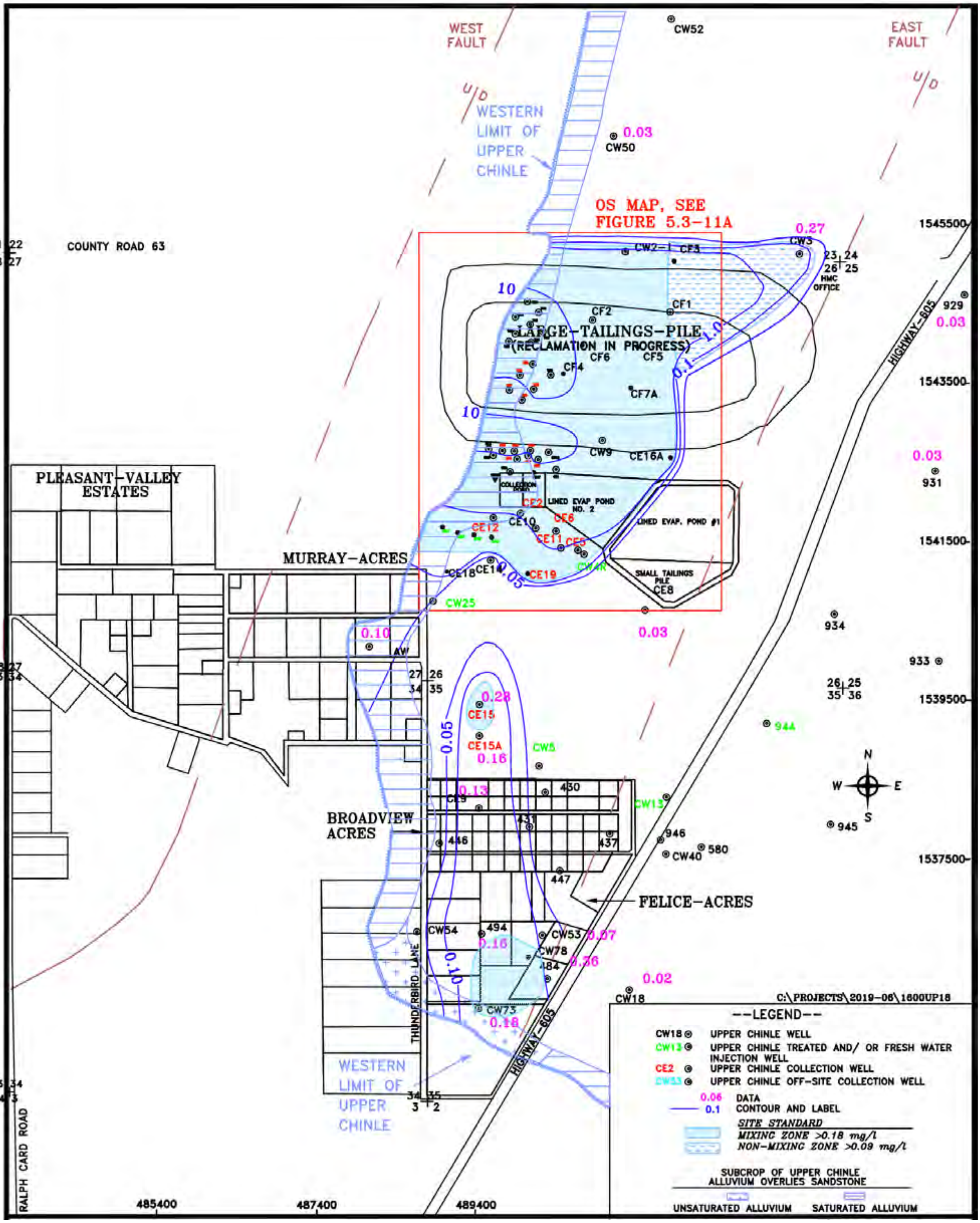
Corrective Action Program

Uranium – milligrams per Liter

Figure 3-35
Uranium Concentrations
Alluvial Aquifer, 2018



Uranium – milligrams per Liter

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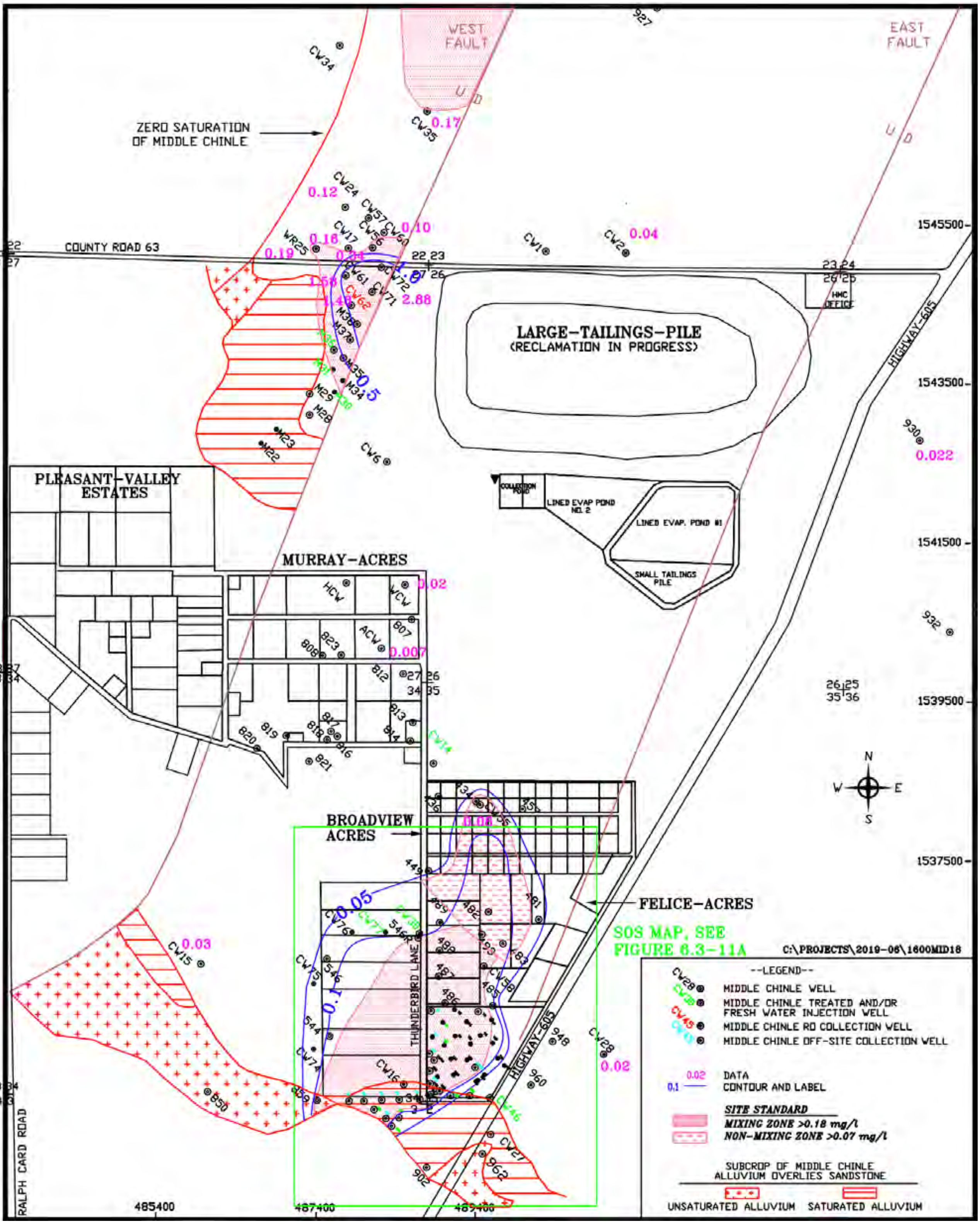
Grants Reclamation Project
Corrective Action Program

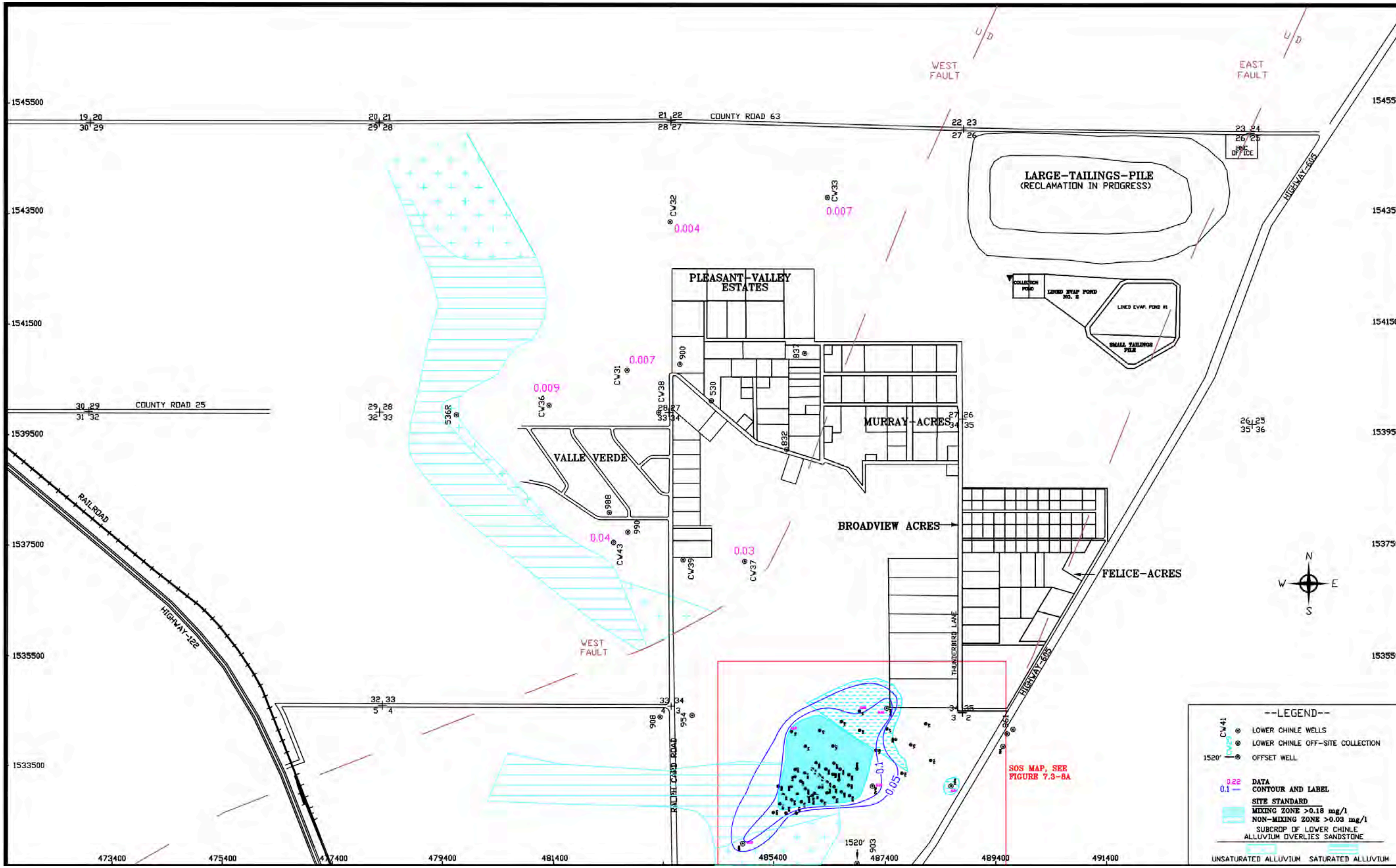
Figure 3-36
Uranium Concentrations
Upper Chinle Aquifer



Uranium – milligrams per Liter

Grants Reclamation Project
Corrective Action Program

Figure 3-37
Uranium Concentrations
Middle Chinle Aquifer



Homestake

Grants Reclamation Project

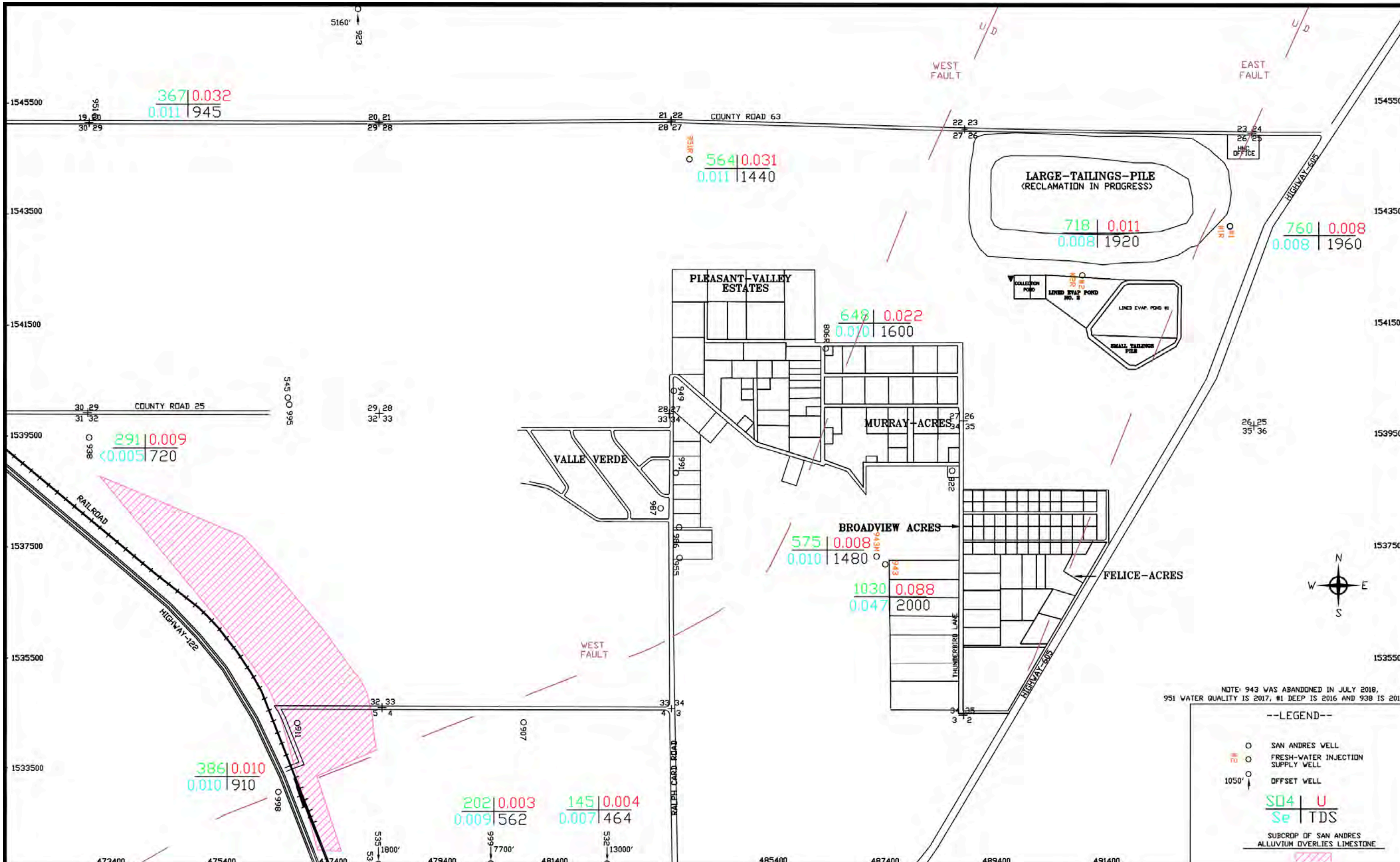
Corrective Action Program

Uranium – milligrams per Liter

Figure 3-38

Uranium Concentrations

Lower Chinle Aquifer, 2018



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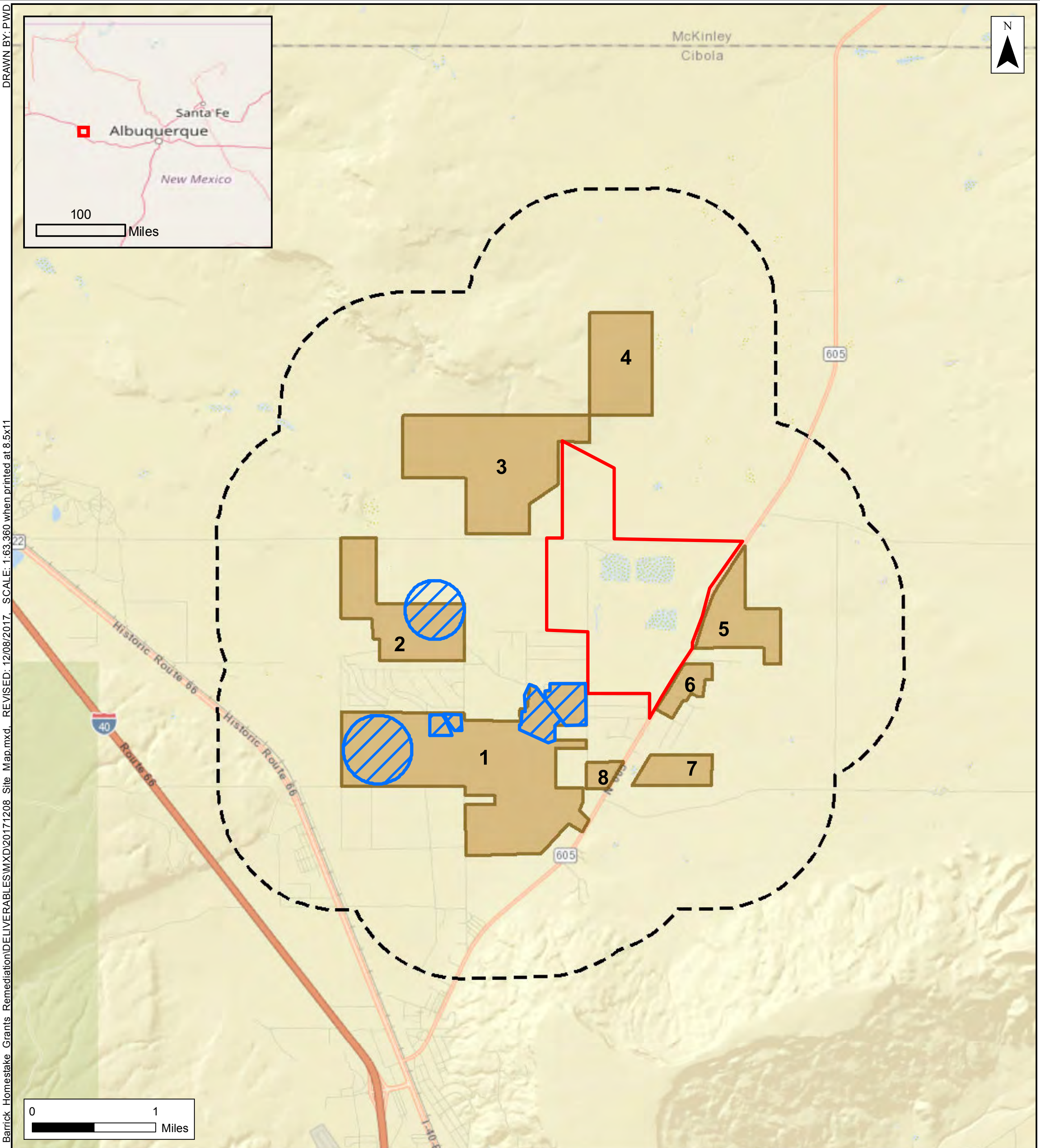
Grants Reclamation Project
Corrective Action Program

Concentration – milligrams per Liter

Figure 3-39
Water Quality
San Andres Aquifer, 2018



Legend

- NRC License Boundary
- Survey Parcels (numbered)
- LTAs
- 1-mile Buffer of Survey Parcels

Source: ERM, 2014

Environmental Resources Management www.erm.com
ERM

Source: Basemap: Esri World Street Map

\\WDWALVS02\Data\Projects\0436775 Barrick Homestake Grants Remediation\DELIVERABLES\MXD\20171208 Site Map.mxd REVISED: 12/08/2017 SCALE: 1:63,360 when printed at 8.5x11 DRAWN BY: PWD

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Corrective Action Program

Figure 3-40
Study Area for Environmental Survey

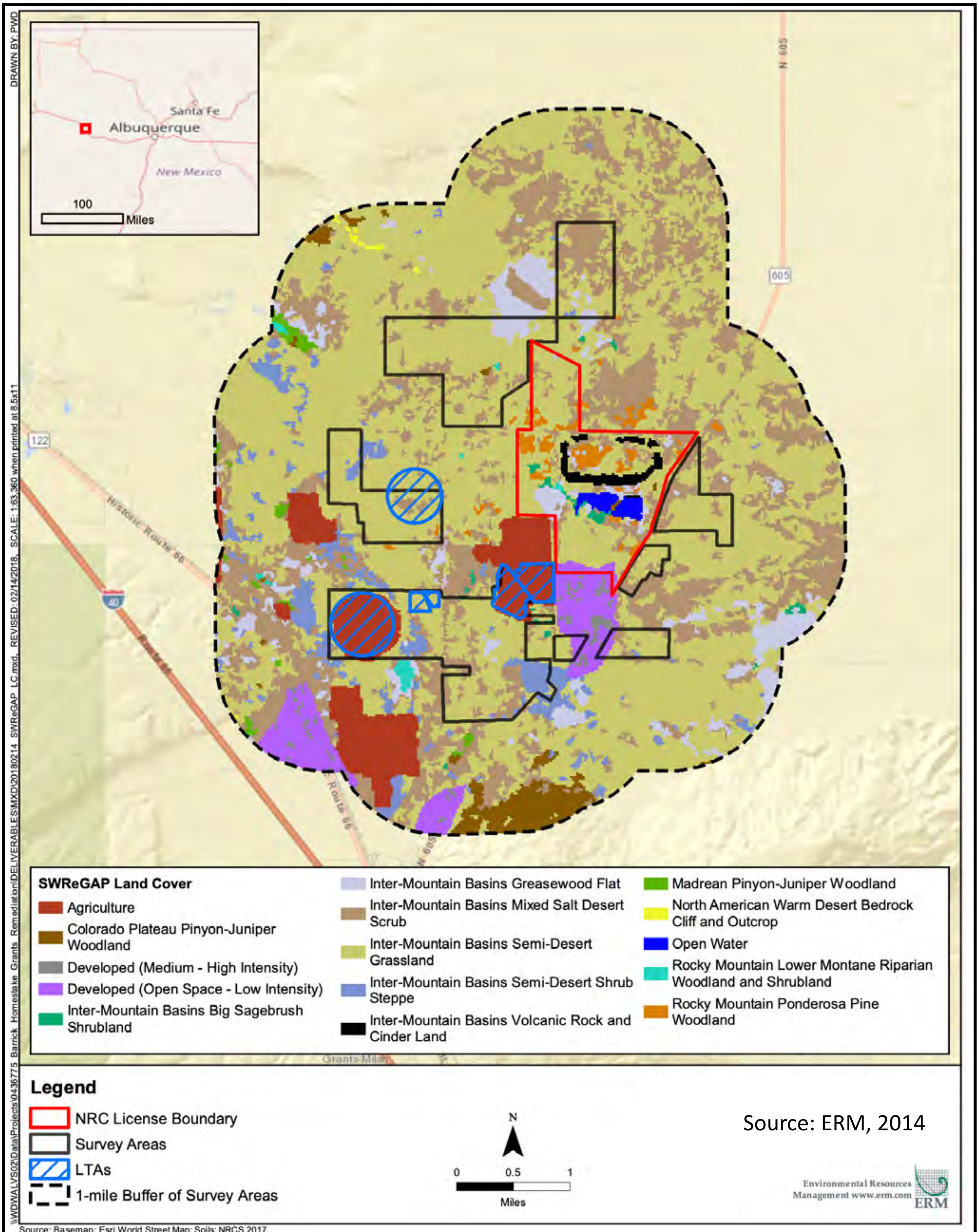

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Figure 3-41
Vegetation Communities

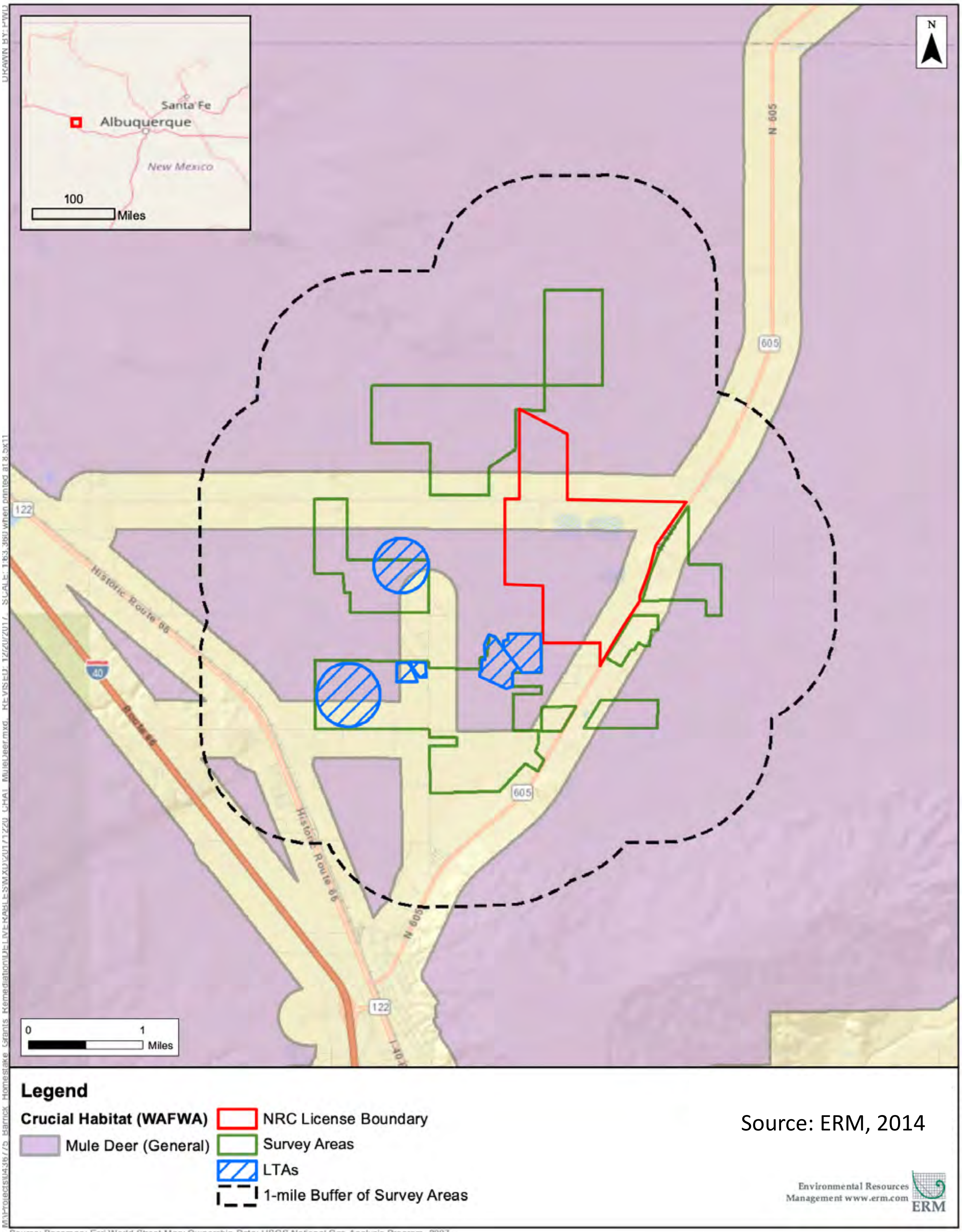

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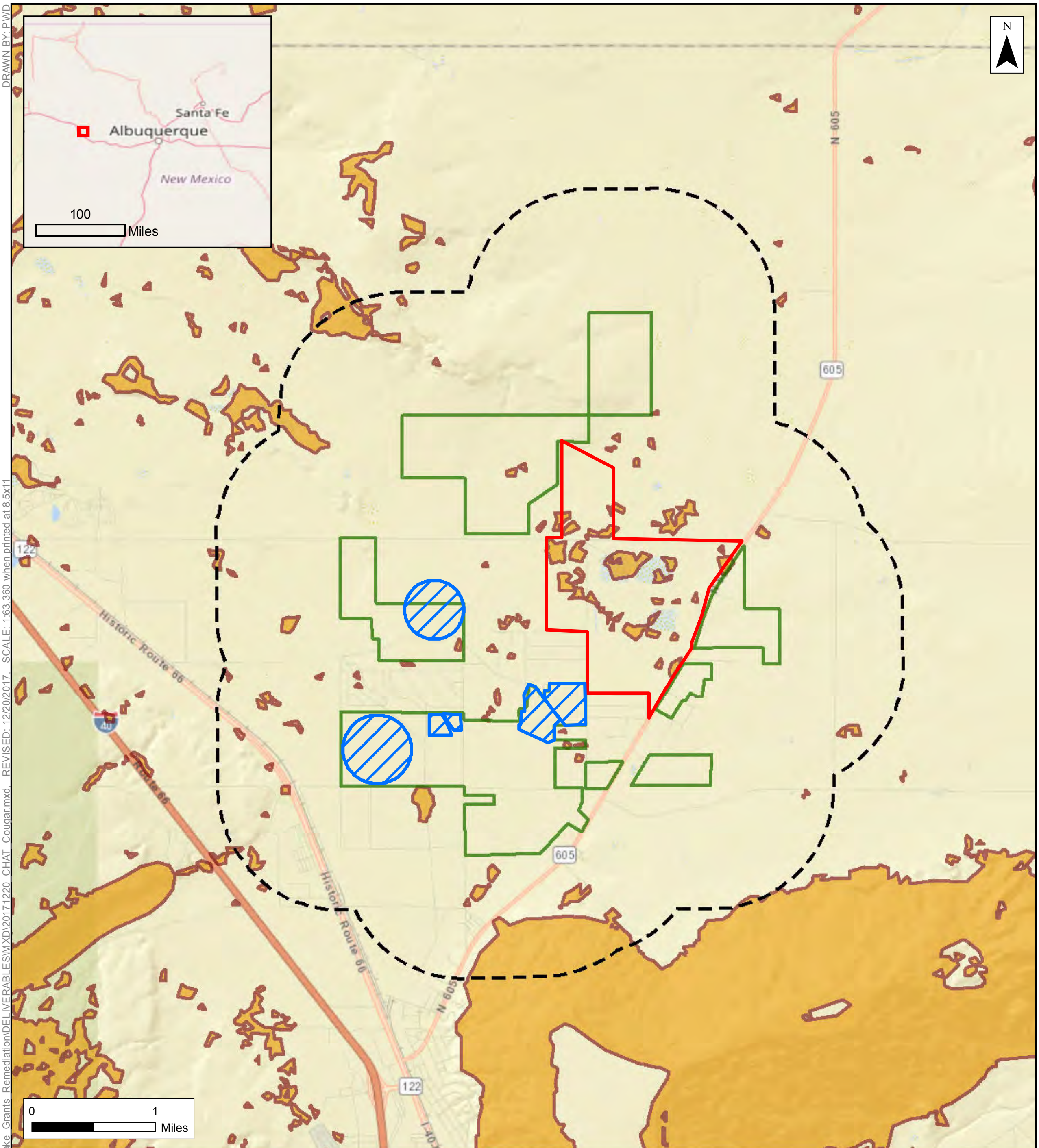
Figure 3-42
Crucial Mule Deer Habitat



Legend

Crucial Habitat (WAFWA)

- Cougar (General)
- NRC License Boundary
- Survey Areas
- LTAs
- 1-mile Buffer of Survey Areas

Source: ERM, 2014

Environmental Resources Management www.erm.com ERM

Source: Basemap: Esri World Street Map; Ownership Data: USGS National Gap Analysis Program. 2007

M:\Projects\0436775 Barrick Homestake Grants Remediation\DELIVERABLES\MXD\20171220 CHAT Cougar.mxd REVISED: 12/20/2017 SCALE: 1:63,360 when printed at 8.5x11 DRAWN BY: PWD

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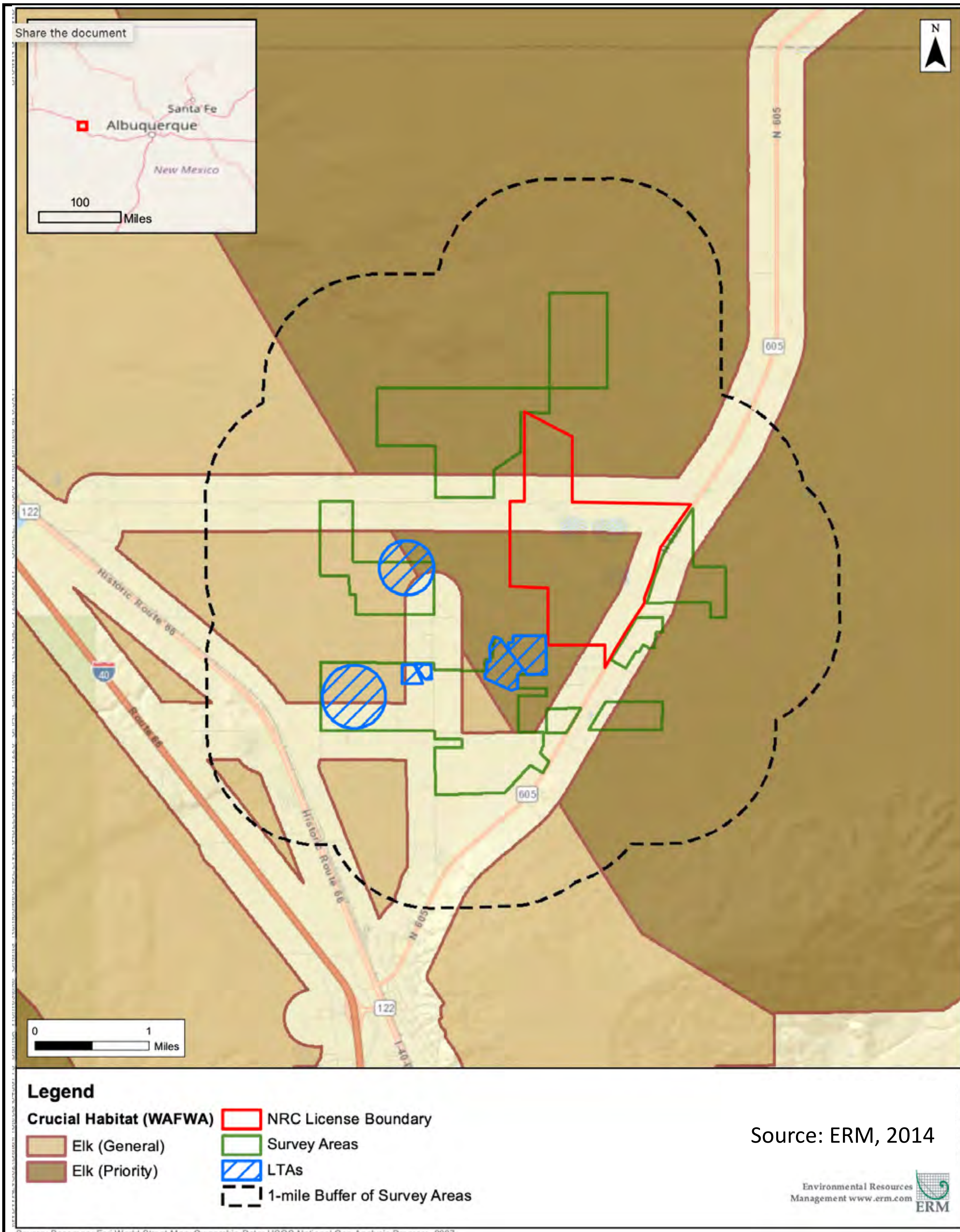
Grants Reclamation Project
Corrective Action Program

Figure 3-43
Crucial Cougar Habitat



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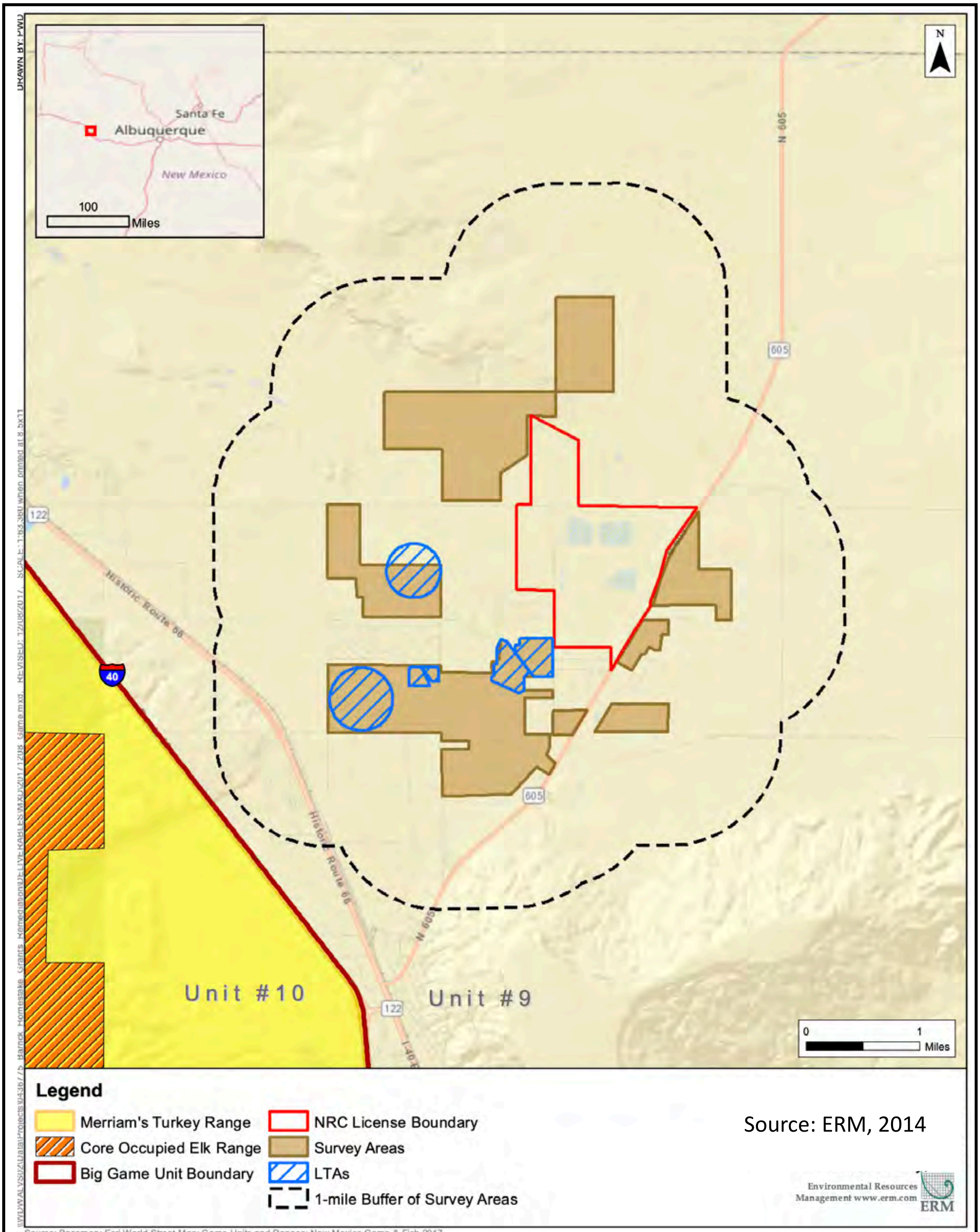
Grants Reclamation Project
Corrective Action Program

Figure 3-44
Crucial Elk Habitat



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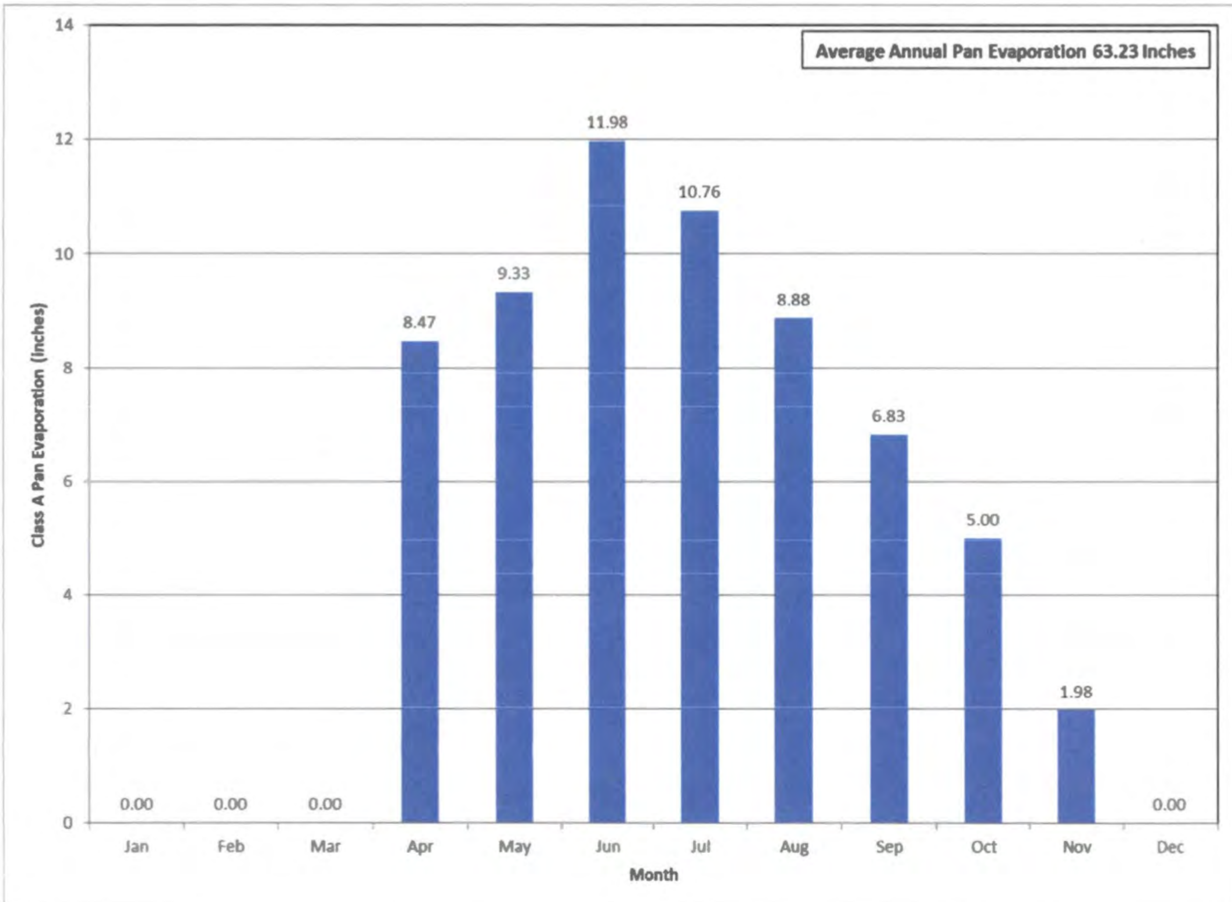
Grants Reclamation Project
Corrective Action Program

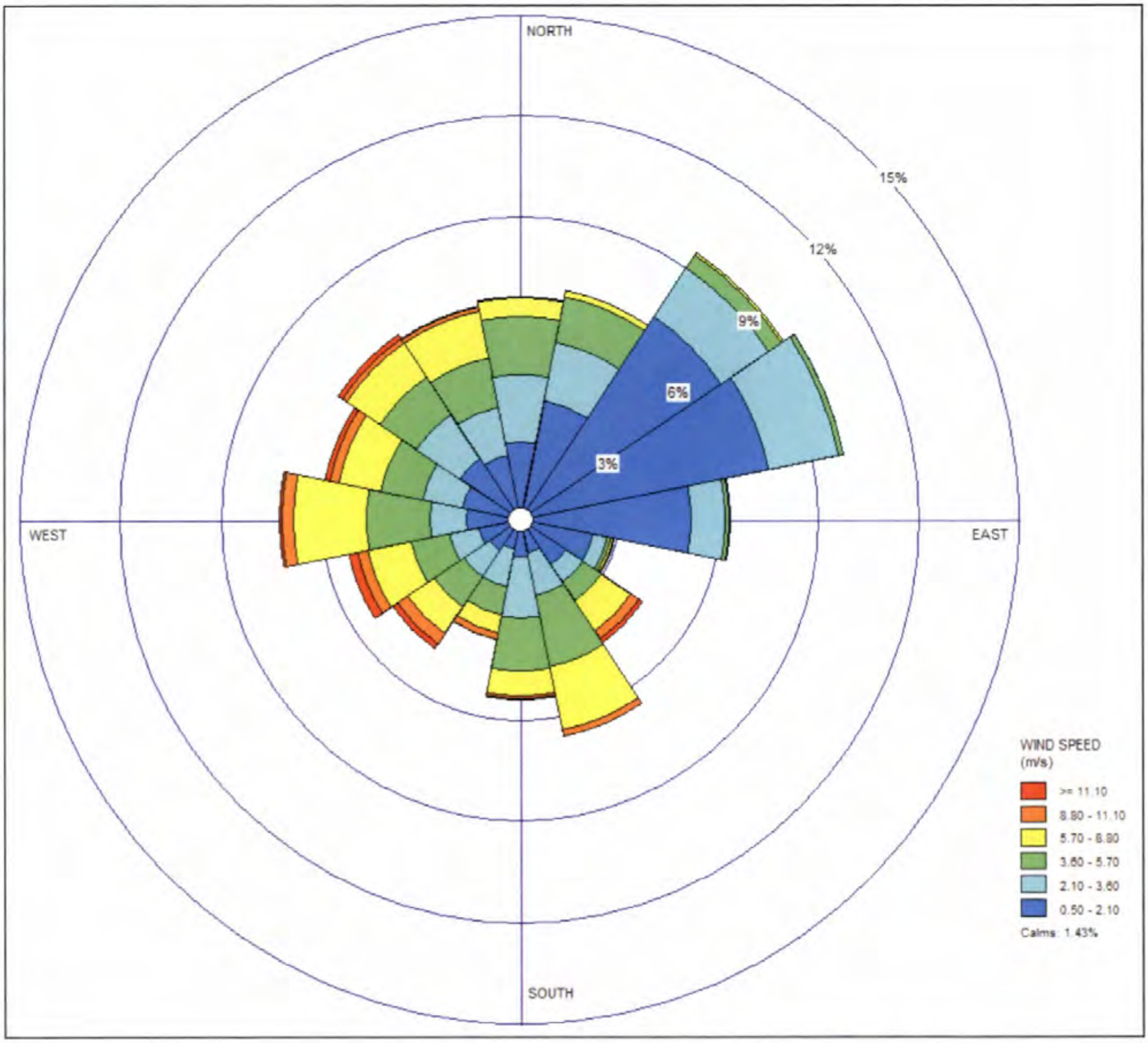
Figure 3-45
Meriam's Turkey Range and Game Units



Source: WRCC, 2019

Grants Reclamation Project
Corrective Action Program

Figure 3-46
Class A Pan Evaporation at Laguna, New Mexico 1914-2005



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Grants Reclamation Project
Corrective Action Program

Figure 3-47
2018 Annual Wind Rose

APPENDIX A

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna Road Ne
Albuquerque, NM 87113-1001
Phone: (505) 346-2525 Fax: (505) 346-2542
http://www.fws.gov/southwest/es/NewMexico/
http://www.fws.gov/southwest/es/ES_Lists_Main2.html

In Reply Refer To: February 19, 2020
Consultation Code: 02ENNM00-2020-SLI-0553
Event Code: 02ENNM00-2020-E-01172
Project Name: Grants Reclamation Project

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

Thank you for your recent request for information on federally listed species and important wildlife habitats that may occur in your project area. The U.S. Fish and Wildlife Service (Service) has responsibility for certain species of New Mexico wildlife under the Endangered Species Act (ESA) of 1973 as amended (16 USC 1531 et seq.), the Migratory Bird Treaty Act (MBTA) as amended (16 USC 701-715), and the Bald and Golden Eagle Protection Act (BGEPA) as amended (16 USC 668-668c). We are providing the following guidance to assist you in determining which federally imperiled species may or may not occur within your project area and to recommend some conservation measures that can be included in your project design.

FEDERALLY-LISTED SPECIES AND DESIGNATED CRITICAL HABITAT

Attached is a list of endangered, threatened, and proposed species that may occur in your project area. Your project area may not necessarily include all or any of these species. Under the ESA, it is the responsibility of the Federal action agency or its designated representative to determine if a proposed action "may affect" endangered, threatened, or proposed species, or designated critical habitat, and if so, to consult with the Service further. Similarly, it is the responsibility of the Federal action agency or project proponent, not the Service, to make "no effect" determinations. If you determine that your proposed action will have "no effect" on threatened or endangered species or their respective critical habitat, you do not need to seek concurrence with the Service. Nevertheless, it is a violation of Federal law to harm or harass any federally-listed threatened or endangered fish or wildlife species without the appropriate permit.

If you determine that your proposed action may affect federally-listed species, consultation with the Service will be necessary. Through the consultation process, we will analyze information contained in a biological assessment that you provide. If your proposed action is associated with Federal funding or permitting, consultation will occur with the Federal agency under section 7(a)(2) of the ESA. Otherwise, an incidental take permit pursuant to section 10(a)(1)(B) of the ESA (also known as a habitat conservation plan) is necessary to harm or harass federally listed threatened or endangered fish or wildlife species. In either case, there is no mechanism for authorizing incidental take "after-the-fact." For more information regarding formal consultation and HCPs, please see the Service's Consultation Handbook and Habitat Conservation Plans at www.fws.gov/endangered/esa-library/index.html#consultations.

The scope of federally listed species compliance not only includes direct effects, but also any interrelated or interdependent project activities (e.g., equipment staging areas, offsite borrow material areas, or utility relocations) and any indirect or cumulative effects that may occur in the action area. The action area includes all areas to be affected, not merely the immediate area involved in the action. Large projects may have effects outside the immediate area to species not listed here that should be addressed. If your action area has suitable habitat for any of the attached species, we recommend that species-specific surveys be conducted during the flowering season for plants and at the appropriate time for wildlife to evaluate any possible project-related impacts.

Candidate Species and Other Sensitive Species

A list of candidate and other sensitive species in your area is also attached. Candidate species and other sensitive species are species that have no legal protection under the ESA, although we recommend that candidate and other sensitive species be included in your surveys and considered for planning purposes. The Service monitors the status of these species. If significant declines occur, these species could potentially be listed. Therefore, actions that may contribute to their decline should be avoided.

Lists of sensitive species including State-listed endangered and threatened species are compiled by New Mexico state agencies. These lists, along with species information, can be found at the following websites:

Biota Information System of New Mexico (BISON-M): www.bison-m.org

New Mexico State Forestry. The New Mexico Endangered Plant Program: www.emnrd.state.nm.us/SFD/ForestMgt/Endangered.html

New Mexico Rare Plant Technical Council, New Mexico Rare Plants: nmrareplants.unm.edu

Natural Heritage New Mexico, online species database: nhnm.unm.edu

WETLANDS AND FLOODPLAINS

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

We encourage you to use the National Wetland Inventory (NWI) maps in conjunction with ground-truthing to identify wetlands occurring in your project area. The Service's NWI program website, www.fws.gov/wetlands/Data/Mapper.html integrates digital map data with other resource information. We also recommend you contact the U.S. Army Corps of Engineers for permitting requirements under section 404 of the Clean Water Act if your proposed action could impact floodplains or wetlands.

MIGRATORY BIRDS

The MBTA prohibits the taking of migratory birds, nests, and eggs, except as permitted by the Service's Migratory Bird Office. To minimize the likelihood of adverse impacts to migratory birds, we recommend construction activities occur outside the general bird nesting season from March through August, or that areas proposed for construction during the nesting season be surveyed, and when occupied, avoided until the young have fledged.

We recommend review of Birds of Conservation Concern at website www.fws.gov/migratorybirds/CurrentBirdIssues/Management/BCC.html to fully evaluate the effects to the birds at your site. This list identifies birds that are potentially threatened by disturbance and construction.

BALD AND GOLDEN EAGLES

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and BGEPA. The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles. Under the BGEPA, the Service may issue limited permits to incidentally "take" eagles (e.g., injury, interfering with normal breeding, feeding, or sheltering behavior nest abandonment). For information on bald and golden eagle management guidelines, we recommend you review information provided at www.fws.gov/midwest/eagle/guidelines/bgepa.html.

On our web site www.fws.gov/southwest/es/NewMexico/SBC_intro.cfm, we have included conservation measures that can minimize impacts to federally listed and other sensitive species. These include measures for communication towers, power line safety for raptors, road and highway improvements, spring developments and livestock watering facilities, wastewater facilities, and trenching operations.

We also suggest you contact the New Mexico Department of Game and Fish, and the New Mexico Energy, Minerals, and Natural Resources Department, Forestry Division for information regarding State fish, wildlife, and plants.

Thank you for your concern for endangered and threatened species and New Mexico's wildlife habitats. We appreciate your efforts to identify and avoid impacts to listed and sensitive species in your project area. For further consultation on your proposed activity, please call 505-346-2525 or email nmesfo@fws.gov and reference your Service Consultation Tracking Number.

Attachment(s):

- Official Species List
- Migratory Birds

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

New Mexico Ecological Services Field Office
2105 Osuna Road Ne
Albuquerque, NM 87113-1001
(505) 346-2525

Project Summary

Consultation Code: 02ENNM00-2020-SLI-0553

Event Code: 02ENNM00-2020-E-01172

Project Name: Grants Reclamation Project

Project Type: WATER QUALITY MODIFICATION

Project Description: Continued restoration of groundwater. Groundwater is pumped from the Chinle formation and injected into the alluvium. Extracted water is run through a reverse osmosis treatment plant and either reinjected or evaporated in one of three evaporation ponds.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/35.231804095070316N107.86921033724666W

Counties: Cibola, NM

Endangered Species Act Species

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Birds

NAME	STATUS
Mexican Spotted Owl *Strix occidentalis lucida* There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/8196	Threatened
Southwestern Willow Flycatcher *Empidonax traillii extimus* There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/6749	Endangered
Yellow-billed Cuckoo *Coccyzus americanus* Population: Western U.S. DPS There is **proposed** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3911	Threatened

Fishes

NAME	STATUS
Zuni Bluehead Sucker *Catostomus discobolus yarrowi* There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/3536	Endangered

Flowering Plants

NAME	STATUS
Pecos (=puzzle, =paradox) Sunflower *Helianthus paradoxus* There is **final** critical habitat for this species. Your location is outside the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/7211	Threatened
Zuni Fleabane *Erigeron rhizomatus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/5700	Threatened

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

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1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Brewer's Sparrow *Spizella breweri* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/9291	Breeds May 15 to Aug 10
Chestnut-collared Longspur *Calcarius ornatus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere

NAME	BREEDING SEASON
Clark's Grebe *Aechmophorus clarkii* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Jan 1 to Dec 31
Golden Eagle *Aquila chrysaetos* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/1680	Breeds Jan 1 to Aug 31
Olive-sided Flycatcher *Contopus cooperi* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/3914	Breeds May 20 to Aug 31
Pinyon Jay *Gymnorhinus cyanocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9420	Breeds Feb 15 to Jul 15
Rufous Hummingbird *selasphorus rufus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8002	Breeds elsewhere

Probability Of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ “Proper Interpretation and Use of Your Migratory Bird Report” before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.

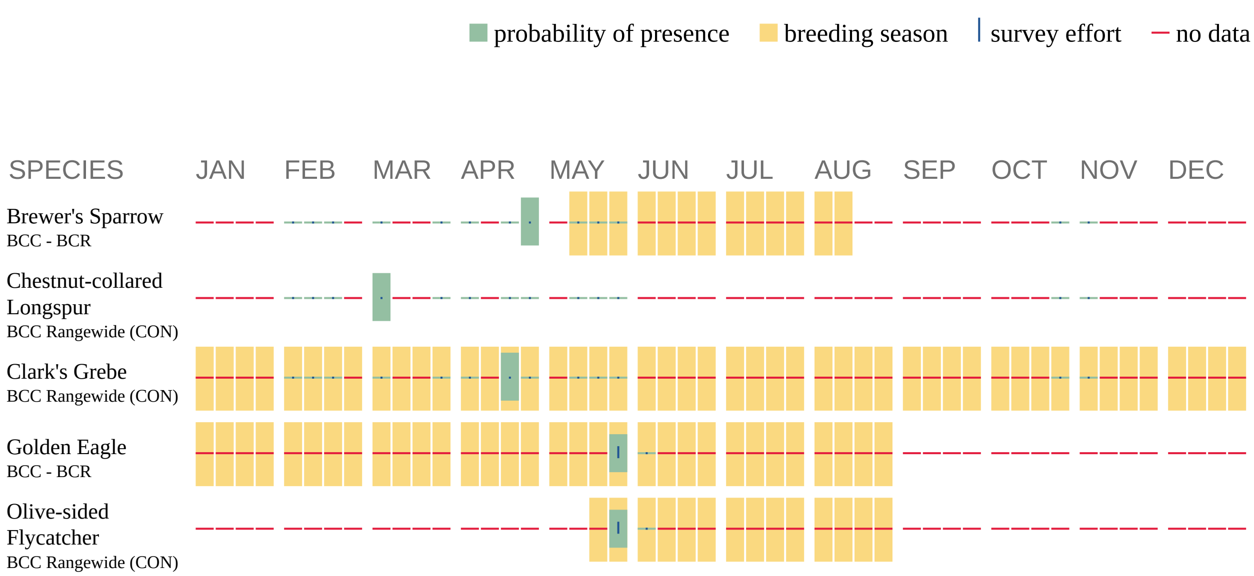
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

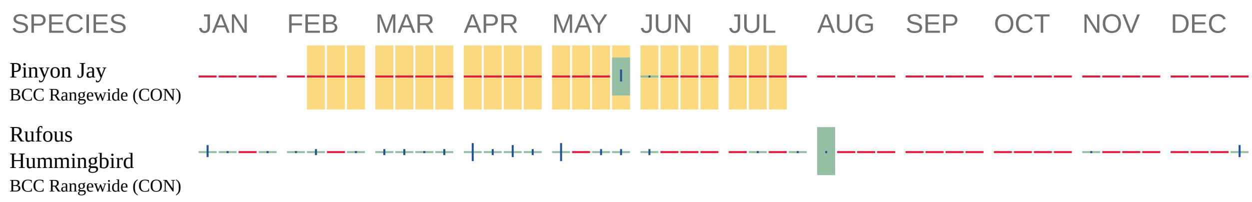
Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.





Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

Migratory Birds FAQ

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the AKN Phenology Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?
The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?
To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?
Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?
If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report
The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ “What does IPaC use to generate the migratory birds potentially occurring in my specified location”. Please be aware this report provides the “probability of presence” of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the “no data” indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ “Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds” at the bottom of your migratory bird trust resources page.