SITE INSPECTION REPORT
PHASE 2
SAN MATEO CREEK BASIN
LEGACY URANIUM MINE AND MILL SITE AREA
CERCLIS ID NMN000606847
CIBOLA-MCKINLEY COUNTIES, NEW MEXICO

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New Mexico Environment Department
Ground Water Quality Bureau
Superfund Oversight Section

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1.0 Introduction

Under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, 42 United States Code (U.S.C.) §§ 9601 to 9675, the New Mexico Environment Department (NMED) Superfund Oversight Section (SOS) conducted a Phase 2 Site Investigation (SI) of the San Mateo Creek Basin legacy uranium mine and mill site area (Site), which is located in Cibola and McKinley counties, New Mexico (CERCLIS ID NMN000606847; Figure 1). The objective of the SI is to evaluate the site using the Hazard Ranking System (Ref. 1) and the Superfund Chemical Data Matrix (SCDM) (Ref. 2) to determine if a threat to human health and the environment exists such that further action under CERCLA is warranted. This SI is considered a Phase 2 as it is a follow up to the Phase 1 SI of June 2010 (Ref. 3)

2.0 Site Information

2.1 Location and Description

The San Mateo Creek basin (Hydrologic Unit Code [HUC] 1302020703), by which the boundary of the Site is defined, comprises approximately 321 square miles within the Rio San Jose drainage basin (Ref. 4, 5) in McKinley and Cibola counties, New Mexico (Ref. 6; see Figure 1). This basin is located within the Grants Mining District (GMD), which is an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval and Bernalillo counties (Ref. 7, p. 8), and includes the Ambrosia Lake mining district (Ref. 7, p. 17). Main access into the Site is provided by New Mexico State Roads 605 and 509.

The 85 legacy uranium mines with recorded production and 4 legacy uranium mill sites comprising the Site (Ref. 8) may have contributed to degradation of ground water quality within this basin. Some background ground water contaminant concentrations associated with remediation of the Homestake Mining Company (HMC) Superfund Site (HMC Site; NMD007860935; Ref. 9) exceed federal (Ref. 10, 11, 12, and 13) and state (Ref. 14) drinking water standards as well as state ground water standards (Ref. 15).

2.2 Geologic setting

This alluvial system extends from the northeast to the south of the HMC site, following the San Mateo Creek drainage (Ref. 16, p. 2-1). The southern end of the San Mateo Alluvial system has been impacted by contamination from the HMC Site. Underlying the Alluvial aquifer in this vicinity is the Upper Triassic (Ref. 7, p. 12) Chinle Formation, which is a predominantly shale formation 800 feet in thickness. Three aquifer units are present within this formation in the southern part of the basin. The highest two aquifers are the Upper and Middle Chinle sandstones. The lowest aquifer, the Lower Chinle, is a fractured shale with variable hydrologic yield of generally poor quality water. All three of these aquifers subcrop with the Alluvial aquifer, connecting the Alluvial aquifer and each of the Chinle aquifers hydrologically in the vicinity of the Homestake site. The San Andres regional aquifer underlies the Chinle Formation in this area (Ref. 16, p. 2-1—2-2).

Most uranium production in New Mexico has come from the Upper Jurassic Westwater Canyon member of the Morrison Formation north of the HMC site in McKinley and Cibola counties (Ref. 7, p. 9; Ref. 17, p. 1, 6). This unit consists of interbedded fluvial arkosic sandstone, claystone, and mudstone with an average thickness of 250 feet, thinning to 100 feet southward and eastward, and is a major aquifer within the GMD (Ref. 7, p. 9). Three types of uranium deposits that are found in the Westwater Canyon member are primary (trend or tabular; average ore grade greater than 0.20% uranium oxide [U_3O_8]), redistributed (stack; average grade 0.16% U_3O_8), and remnant-primary (average grade 0.20% U_3O_8; Ref. 17, p. 6, 8). The overlying Brushy Basin member of the Westwater Canyon member includes the Poison Canyon Sandstone, from which uranium also has been mined (Ref. 7, p. 9, 13).

Additionally uranium deposits were discovered at Haystack Butte in 1950 within the Upper Jurassic Todilto Limestone, which occurs within the San Raphael Group underlying the Morrison Formation (Ref. 7, p. 12, 13; Ref. 17, p. 4); these accounted for approximately 2% of production from the Grants uranium district between 1950 and 1981 (Ref. 17, p. 11). More than 100 uranium mines and occurrences in the Todilto Limestone are documented in New Mexico, with production reported from 42 of these mines—mostly located within the Grants uranium district (Ref. 17, p. 12).

Thin zones of minor uranium mineralization have been produced from shale and lignite within the Lower Cretaceous Dakota Sandstone, which overlies the Morrison Formation (Ref. 7, p. 13; Ref. 17, p. 12). Uraniferous collapse-breccia pipe deposits, which are vertical or steeply-dipping cylindrical features bounded by ring fractures and faults filled with heterogeneous brecciated country rock, also are found in the Grants area (Ref. 17, p. 12).

Quaternary-age unconsolidated to semi-consolidated alluvial, eolian, and terrace deposits overlie bedrock in valley bottoms; these deposits are generally less than 200 feet in thickness (Ref. 7, p. 13, Figure 2).

2.3 Demographics

Average household size within McKinley County is 3.22 people (Ref. 18); average population density is 13 people/square mile (Ref. 19, p. 1). Within Cibola County, the average household size is 2.79 people (Ref. 20, p. 1); the average population density in Cibola County is 6 persons/square mile (Ref. 19, p. 2).

The community of San Mateo, which is located within the San Mateo Creek basin, has a municipal water supply that serves 192 residents (Ref. 21, p. 1). No demographic data for the community of Haystack were found.

The communities of Grants, Milan, and Bluewater are located just outside of the boundaries of the Site. In the 2010 Census, Grants reported a population of 9,182 people with average household size of 2.54 people (Ref. 22). Milan reported a population of 3,245 in 2010 Census with an average household size of 2.7 people (Ref. 23). No population data were found for Bluewater.

2.4 Climate

The average annual maximum temperature at the Grants Airport is 67.8° F; the highest maximum temperature of 88.4° F occurs in July. The average annual minimum temperature is 33.0° F; the lowest minimum temperature of 14.4° F occurs in December. The average annual total precipitation is 10.40 inches (in.). The maximum average precipitation of 2.03 in. occurs in August; the minimum average precipitation of 0.44 in. occurs in February. Average annual snowfall is 12.3 in., with the maximum snowfall of 4.1 in. occurring in December (Ref. 24).

The average annual maximum temperature at the weather station in San Mateo, New Mexico is 61.7° F; the highest maximum temperature of 83.1° F occurs in July. The average annual minimum temperature is 34.6° F; the lowest minimum temperature of 16.0° F occurs in January. The average annual total precipitation is 8.66 in. The maximum average precipitation of 2.11 in. occurs in August; the minimum average precipitation of 0.28 in. occurs in February and December. Average annual snowfall is 9.7 in., with the maximum snowfall of 3.1 in. occurring in December (Ref. 25).

The prevailing wind direction (i.e., the direction from which the wind blows) at the Grants airport is northwesterly (Ref. 26, p. 10). At a monitoring location within Bluewater Creek (elevation 7,624 feet), the prevailing wind direction was west-southwesterly during 2007, at an average speed of 9.0 miles per hour (mph) (Ref. 27, p. 2). At a nearby monitoring location on Bluewater Ridge, the prevailing wind direction is south-southwesterly at an average speed of 4.3 mph (Ref. 28, p. 2).

2.5 Operational history and ownership

Uranium ore was discovered in the Todilto Limestone at Haystack Butte in 1950, and production began prior to mill construction in the area by open-pit mining. Uranium was discovered at Ambrosia Lake in 1955 (Ref. 17, p. 4). Downdip drilling from the initial surface discoveries delineated ore bodies within the Poison Canyon and Westwater Canyon members of the Morrison Formation. The discovery of large subsurface uranium deposits within the Westwater Canyon member resulted in establishment of two-thirds of the active uranium mines in New Mexico within the Ambrosia Lake district by 1980; most of these mines were underground room-and-pillar operations at depths averaging 900 feet (Ref. 7, p. 17).

The Anaconda Copper Company built the Bluewater mill in 1953 to process ore from the Jackpile mine (Ref. 17, p. 4; Ref. 29, p. 1). This mill used a carbonate-leach process with a capacity of 300 tons per day and operated until 1959. An acid-leach mill was operated from 1957 through 1982, reaching a production capacity of 6,000 tons per day in 1978 (Ref. 29, p. 1). Atlantic Richfield Company (ARCO) Coal Company reclaimed the site between 1991 and 1995 for long-term DOE stewardship under the Legacy Management program (Ref. 17, p. 5; Ref. 29, p. 1-2).

Two mills were built in 1957 at the present Homestake mill site. The first closed in 1962. Homestake originally owned the second larger mill in a partnership; when that partnership was dissolved in 1981, Homestake became the sole owner. Mill production ceased in 1981, but resumed in 1988 to process ore from the Section 23 mine and Chevron's Mount Taylor mine. The mill was demolished in 1990 (Ref. 17, p. 5), and the site ground water restoration is ongoing (Ref. 30). In 2001, Homestake merged with Barrick Gold Corporation (Ref. 17, p. 5).

Kermac Nuclear Fuels Corp., which was a partnership of Kerr-McGee Oil Industries, Inc., Anderson Development Corp., and Pacific Uranium Mines Co., built the Kerr-McGee uranium mill at Ambrosia Lake in 1957-58. Quivira Mining Co., a subsidiary of Kerr-McGee Corp. (later Rio Algom Mining LLC, currently BHP-Billiton) became the operator of the mill in 1983. Operation began in 1958; from 1985 through 2002 the mill produced only from mine waters from the Ambrosia Lake underground mines. (Ref. 17, p. 5). The tailing impoundment at the site contains 33 million tons of uranium ore (*sic*) within an area of 370 acres (Ref. 31).

Phillips Petroleum Co. built a mill at Ambrosia Lake in 1957-58, and began to process ore from the Ann Lee, Sandstone, and Cliffside mines in 1958. United Nuclear Corporation acquired the property in 1963 when the mill closed (Ref. 17, p. 5). United Nuclear Corporation operated an ion exchange system to extract uranium from mine water in the late 1970s to early 1980s. All operations ended in 1982 (Ref. 32, p. 1).

2.6 Regulatory history

Some mines are inventoried by the New Mexico Bureau of Geology and Mineral Resources, the Navajo Nation Abandoned Uranium Mine (AUM) program, and/or the U.S. Bureau of Land Management; some mine sites also have been reclaimed under Federal or State jurisdiction (Ref. 8).

In 1978, the U.S. Environmental Protection Agency (EPA) proposed to regulate mine water discharge under the National Pollutant Discharge Elimination System (NPDES) permit program. The permit for the Kerr-McGee Section 35 and 36 mines was terminated when Kerr-McGee undertook controlled spreading and irrigation with mine dewatering effluent. Kerr-McGee obtained a State ground water discharge permit for ion exchange (IX) facilities associated with the Section 35 and 36 mines in 1979-1980; this permit currently is in stand-by status (Ref. 33, p. 2).

The Bluewater Mill site was remediated by the ARCO under the U.S. Nuclear Regulatory Commission (NRC) operational license, and was subsequently transferred to DOE custody and long-term care in 1997 (Ref. 34) under the jurisdiction of Title II of the Uranium Mill Tailings Radiation Control Act (UMTRCA); (Ref. 29, p. 1). Prior to this transfer, the NRC amended the operational license to include alternate concentration limits (ACLs) for the Alluvial and San Andres aquifers, which were impacted by the site, at established point of compliance wells (Ref. 29, p. 2; Ref. 35, p. 1, 3, and 4).

Homestake Mining Company is currently remediating the Homestake uranium mill site under the regulation of NRC license SUA-1471 and NMED discharge permit DP-200 (Ref. 30, p. 1.1-1). This site also is on the National Priorities List (NPL) (CERCLIS ID NMD007860935; Ref. 36, p. 17).

The site status of the Ambrosia Lake/Rio Algom mill was changed to reclamation in August 2003. NRC issued a license amendment for ACLs in February 2006, after which all ground water corrective actions were discontinued under the NRC (Ref. 31). In addition to regulation under NRC, the Rio Algom mill and mine sites are regulated under State Ground Water Discharge Permits (DP) under the authority of the State Water Quality Act (Ref. 37) and the New Mexico Water Quality Control Commission Regulations (Ref. 15). Currently, DP-169 addresses the mill site, including any potential associated off-site contamination. DP-362 covers old stope leaching operations at 10 mines and associated ground water abatement activities. DP-67 addresses dewatering of the Section 35 and 36 mines while DP-264 was approved for backfilling of these mines, and associated ground water abatement activities. DP-71 was approved for closure of the Section 4 evaporation ponds associated with the mill. NMED and Rio Algom are discussing the possibility of consolidating ground water discharge permits, but this has not been finalized to date (Ref. 38 and 39)

The DOE remediated the Ambrosia Lake/Phillips mill site between 1987 and 1995 as part of the 1978 UMTRCA Title I program, and currently monitors the site as part of the Legacy Management program (Ref. 17, p. 5; Ref. 32, p. 1-2; Ref. 40).

2.7 Previous environmental investigations

Numerous environmental investigations associated with remediation of the 4 mill sites within the Site have been conducted under the regulatory authority of the NRC; documents from these investigations are not detailed herein, but many are available through the ADAMS website interface (http://adamswebsearch.nrc.gov/scripts/securelogin.pl).

The New Mexico Health and Environment Department (EID), predecessor agency to the NMED, documented a study of the uranium mining impacts on surface and ground water within the Grants mineral belt in 1986 (Ref. 7).

The New Mexico Energy, Minerals and Natural Resources Department (NMEMNRD) has compiled a database of uranium legacy mine and mill site information from multiple sources (Ref. 8), which forms the basis of this investigation. The locations of the mines with reported production and mills from this database are shown on Figure 1. Other mine sites without reported production in this database are not addressed herein.

The U.S. Forest Service proposed CERCLA investigation of the San Mateo mine in 2008 (Ref. 41, p. 21).

Strathmore Resources currently is conducting baseline studies within the San Mateo Creek basin for proposed uranium exploration and development activities (Ref. 42).

Under CERCLA, individual mine- and mill sites within the Site boundary have been investigated and are summarized in Figure 5. NMED has conducted a Preliminary Reassessment, July 2008 (Ref. 43) and a Site Investigation, August 2009 (Ref. 44) of the Anaconda Bluewater mill site, and a Preliminary Assessment of the Ambrosia Lake—Phillips mill site, March 2009 (Ref. 45).

Previous to this Phase 2 SI, NMED conducted and documented a pre-CERCLIS screen, January 2008 (Ref. 46) and Preliminary Assessment, March 2008 (Ref. 47) of the San Mateo Creek basin legacy uranium sites, and completed a Phase 1 Site Investigation in 2010 which is the precursor to this Phase 2 SI (Ref. 3).

The Phase 1 Site Investigation was conducted for the San Mateo Creek Legacy Uranium Sites and is documented in a Report dated June 2010 (Ref. 3). For the Phase 1 SI, during the week of March 30, 2009, NMED SOS personnel collected ground water samples from 28 residential and livestock wells within the San Mateo Creek basin north of the HMC Site; one additional well sampled for this investigation yielded only enough water for isotopic analysis. In the conclusion section of the June 2010 SI, it stated that all ground water samples collected for the SI had at least one contaminant concentration exceeding a respective MCL (Ref. 3, Tables 5 7 6.). More information from the Phase 1 SI is provided below in the Local Ground Water Quality Section.

The EPA Region 6 has conducted Aerial Spectrophotometric Environmental Collection Technology (ASPECT) aerial radiological surveys in the SMC basin in October 2010 and in the summer of 2011. EPA conducted Documented Release sampling at the John Bully-Sandstone Mines and the Section 12-Dysart Mines in 2011. EPA conducted adjacent land-Jackson Property sampling next to the Johnny M Mine in 2011. In early 2012 EPA conducted Documented Release sampling at the Johnny M Mine.

In addition to environmental investigations under CERCLA, there have been numerous investigations that have been compiled in an annotated bibliography (Ref. 48.

3.0 Site Investigation

3.1 Source/Waste Characteristics

3.1.1 Source Waste Identification and Description

Both surface and underground mining methods contributed waste to natural surface drainage systems. Liquid wastes were almost exclusively derived from underground operations, while both operational methods contributed solid wastes. Underground mines generally produce less waste rock than surface mines, but contaminant concentrations can be higher (Ref. 7, p. 19). Mine waste piles may include barren overburden, low-grade ore (i.e., below economic value), and/or ore stockpiled for later milling (Ref. 7, p. 54). The spoils areas in which this waste rock is stored usually were not bermed to control runoff (Ref. 7, p. 19). EID sampled mine wastes from mine sites within the Site to test contaminant leachability (Ref. 7, p. 32-33). Leaching testing from 37 composite samples of uranium mine waste that were designed to simulate the leaching effects of natural rainfall both before and after contacting alkaline rich soils indicated that contaminants have a relatively low potential for leaching or for significantly degrading ground water quality (Ref. 7, p. 57).

A 1985 survey of 14 uranium mines located within the GMD, which includes individual mine sites located within the Site, on Federally-owned surface and mineral lands showed gamma radiation levels between 6 and 888 microroentgens per hour, with the highest reading taken from mine waste and openings (Ref. 49, p. 2-4).

3.1.1 Source Waste Characterization Methods and Results

Source wastes were identified by review of existing literature on mining/milling activities in the San Mateo Creek Basin. No samples were collected from a potential waste source for this SI. The results of various studies are provided below which describe potential sources for releases of hazardous substances.

Sampling results of waste rock materials from the Poison Canyon Mining District are summarized in Table 2. Nearly all contaminant concentrations in the waste materials are higher than in the background samples by one to two orders of magnitude (Ref. 50). Waste material from the Navajo-Brown Vandever uranium mine (CERCLIS ID NMD986669117) was used to pave the road to this site, and approximately 75 people were identified to live with one-quarter mile of this site in 1990 (Ref. 51).

EID investigators concluded that 10 to 20 percent of all abandoned mines in the GMD had waste piles that are directly eroding into local drainage channels (Ref. 7, p. 55). EID collected runoff samples from several sites to assess contaminant input from mine waste piles within the Ambrosia Lake mining sub-district (Ref. 7, p. 54); observations from this program indicated that runoff contaminant concentrations exceeded natural concentrations by up to several hundred times. Samples collected within the Ambrosia Lake mining sub-district indicated that uranium and molybdenum maxima concentrations in waste pile runoff exceed natural runoff concentrations by over 2 orders of magnitude. Maximum arsenic, selenium, and vanadium concentrations exceed maximum natural runoff concentrations by 6 to 8 times (Ref. 7, p. 54-55). Runoff sampling in the vicinity of a large waste pile associated with the Old San Mateo mine showed elevated levels of gross alpha and gross beta particle activities, ^{226}radium, natural uranium, arsenic, lead, molybdenum, selenium, and vanadium, in comparison to natural sediments, to persist at least 550 meters downstream from the waste pile (Ref. 7, p. 57).

Water produced from mine dewatering and aquifer depressuring operations was discharged to settling ponds and drainage channels (Ref. 7, p. 20-21). Mine water production within the Ambrosia Lake mining district was continuous after 1956, with peak production in the early 1960s (Ref. 7, p. 66). During the period 1979-1981, mine discharges of 1,500 gallons per minute (gpm) to San Mateo Creek sustained approximately 3 miles of perennial flow; 2,300 gpm discharge to Arroyo del Puerto sustained perennial flow of approximately 5 miles (Ref. 7, p. 66, 68). In 1977, approximately 2,900 gpm were being discharged to San Mateo Creek from mine dewatering; by spring of 1978, most of this water was diverted for irrigation and to an adjacent drainage basin (Ref. 7, p. 72).

Raw mine waters from the GMD had elevated concentrations of gross alpha and beta particle activities, ^{226}radium, ^{210}lead, natural uranium, molybdenum, selenium, and dissolved solids—particularly sulfate; elevated concentrations barium, arsenic, and vanadium also were observed. Total dissolved solid (TDS) concentrations in mine waters from the western part of the Ambrosia Lake mining district were 1,200 to 1,800 milligrams per liter (mg/L). Mine water in eastern part of the Ambrosia Lake mining district usually had a few hundred mg/L TDS (Ref. 7, p. 80).

For compliance with federal NPDES permits, produced waters were treated with the additions of a flocculent and barium chloride to reduce suspended solid concentrations and to co-precipitate radium (Ref. 7, p. 20-21). Effluent discharged to San Mateo Creek contained 300 to 600 mg/L TDS. Out of nine trace elements for which treated mine waters were analyzed, molybdenum, selenium, and uranium concentrations were consistently higher than in natural runoff. Median total uranium concentration in mine effluents from the Ambrosia Lake mining district was 1.6 mg/L, which was over 16 times greater than the corresponding median concentration in natural runoff. Median total molybdenum concentration in mine water from the Ambrosia Lake mining district was 0.80 mg/L, which compares to the few samples of natural runoff in which total molybdenum concentration exceeded 0.01 mg/L. Total median selenium concentrations in treated mine water generally are less than 0.04 to 0.09 mg/L; however some treated effluents within the district approach 1.0 mg/L. Median total selenium concentration in natural runoff within the Ambrosia Lake mining district is 0.03 mg/L. Arsenic, vanadium, and barium, the latter of which is added in the treatment process, are occasionally detected in significant concentrations in mine waters; cadmium, lead, and zinc are usually below detectable concentrations (Ref. 7, p. 87). Median total barium concentration in treated mine water was 0.212 mg/L, which was lower than the 7.7 mg/L concentration in natural runoff (Ref. 7, p. 90). Elevated concentrations of arsenic and vanadium in treated effluent (0.05 and 0.17 mg/L, respectively) were only observed in association with the Homestake ion exchange facility, which was located within the Ambrosia Lake area (Ref. 7, p. 87, 97).

With the exception of natural uranium, total concentrations of radionuclides in treated mine waters are less than those in natural runoff. Most mines discharged mine waters with total concentrations of ^{226}radium of 6 picocuries per liter (pCi/L) or less; about 30 percent of this may have been in the dissolved form. However, EID collected effluent samples with total ^{226}radium concentrations up to 200 pCi/L; these higher concentrations were attributed to the existence of upset conditions in the treatment process. Neither thorium isotopes nor ^{228}radium were generally present in detectable concentrations. Total ^{210}lead concentrations up to 33 pCi/L and total ^{210}polonium concentrations up to 15 pCi/L were detected from treated mine waters; higher concentrations—up to several hundred pCi/L—may have occurred during periods of ineffective mine water treatment (Ref. 7, p. 90).

Generally treated mine waters contained trace elements and radionuclides in dissolved form; typically, these dissolved contaminant concentrations comprised more than 50% of the total. More than 85% of the total concentration of gross alpha activity, molybdenum, selenium and natural uranium occurred in the dissolved fraction, while ^{226}radium concentrations averaged about 30% of the total (Ref. 7, p. 87). With the exception of natural uranium, radionuclide concentrations in mine waters in the dissolved phase were higher in comparison to concentrations in natural runoff (Ref. 7, p. 90). Dissolved gross alpha levels were several hundred to over 1,000 pCi/L in dewatering effluents (Ref. 7, p. 90). Only ^{226}radium and ^{210}lead, among trace elements and radionuclides identified to have had elevated concentrations in effluent, underwent significant partitioning changes between dissolved and suspended phases with distance traveled; these constituents usually bound to precipitates and sediments and were lost from solution shortly after release. Once precipitated or bound to stream sediments, mine water contaminants could be moved downstream during natural or artificially-induced flow events. (Ref. 7, p. 90, 92). Within relatively sediment-free stream channels, these contaminants would stay in solution; dissolved ^{226}radium concentrations along the Arroyo del Puerto ranged between 3 and 6 pCi/L. Dissolved ^{226}radium concentrations also were attenuated by the alkaline and oxidizing conditions that are found in the GMD (Ref. 7, p. 109). Concentrations of uranium, molybdenum, and major dissolved solids generally were not rapidly attenuated in the receiving stream channels (Ref. 7, p. 92).

Mechanisms that were inferred to reduce contaminant concentrations most effectively in alluvial ground water impacted by mine water effluents include dilution, surface adsorption, cation exchange, precipitation, hydrodynamic dispersion, and molecular diffusion.

Sludges in treatment ponds that are created from settling, flocculation, and precipitation have elevated concentrations of ^{226}radium and other radionuclides, with concentrations of the former exceeding 200 pCi/gram (Ref. 7, p. 82). Separate ion-exchange treatment reduced elevated concentrations of dissolved uranium (Ref. 7, p. 20-21). Although treatment reduced concentrations of ^{226}radium, ^{210}lead, ^{210}polonium, natural uranium, and gross alpha activity, other constituent concentrations were not affected (Ref. 7, p. 80).

3.2 Ground Water Pathway

The ground water pathway assesses the threat to human health and the environment by determining whether hazardous substances are likely to have been released to ground water and whether any receptors are likely to be exposed to hazardous substances as a result of a release.

3.2.1 Hydrogeology

Alluvial aquifers along San Mateo Creek generally yield less than 50 gpm, where water occurs from a few feet to 100 feet below the surface (Ref. 7, p. 14). Available data indicate the presence of little alluvial ground water along the Arroyo del Puerto under pre-mining conditions (Ref. 7, p. 95). Near Ambrosia Lake, the Alluvial aquifer presently yields less than 150 gallons per day (gpd), and is expected to return to pre-mining/pre-milling conditions of little to no saturation (Ref. 32, p. 2). Alluvial ground water flows generally correspond to the slope of the land along San Mateo Creek (Ref. 7, p. 14). Depths to ground water in 1981 along San Mateo Creek were generally near 60 ft near its intersection with the tributary Arroyo del Puerto. Along the latter watercourse, 1981 depths to water were approximately 24 ft (Ref. 7, p. 16). Measurements conducted near the San Mateo Creek gaging station in 1980 showed little effect on alluvial ground water levels from intense summer thunderstorms, but did demonstrate a hydraulic response to late winter and spring stream flow (Ref. 7, p. 74).

Bedrock aquifers are recharged where streamflows or mine water discharge intersect bedrock subcrops and outcrops (Ref. 7, p. 13, 77). Additional bedrock aquifer recharge occurs where saturated valley fill overlie permeable bedrock with a downward hydraulic gradient (Ref. 7, p. 77). Mine dewatering has decreased aquifer water levels significantly, especially in the Morrison Formation (Ref. 7, p. 13). The

Westwater Canyon member of the Morrison Formation is a principal bedrock aquifer in the area, yielding up to several hundred gpm (Ref. 7, p. 13). Mine dewatering drained virtually all of this formation and altered its flow system. Prior to dewatering, ground water generally flowed to the northeast and east in the direction of the dip of the strata (Ref. 52, p. 3). Other reliable aquifers include the Dakota Sandstone, the Glorieta Sandstone, and the San Andres Limestone.

3.2.2 Local Ground Water Quality

Ground water data from the period preceding the inception of mining were limited to single-event sampling of isolated windmills for general chemical characteristics, such as sulfate and TDS, and no trace element or radionuclide data are available in the San Mateo Creek (Ref. 7, p. 94) and the Arroyo del Puerto (Ref. 7, p. 95) drainages. Pre-mining alluvial ground water quality was assessed by data obtained from wells located upstream of uranium industry activities, including the Lee wells along San Mateo Creek. These data indicate that natural alluvial ground waters along San Mateo Creek trend from sodium bicarbonate water at the Lee Ranch to sodium-sulfate-bicarbonate water downstream at the Sandoval Ranch windmill. TDS concentrations increase from 540 to 650 mg/L within this 6-mile distance (Ref. 7, p. 95). Molybdenum concentrations in water from the Lee wells were consistently less than 0.010 mg/L (Ref. 7, p. 95). Uranium concentrations also were consistently less than 0.010 mg/L in these alluvial wells. At the Sandoval Ranch, pre-mining uranium concentrations were estimated to have been less than 0.030 mg/L. The EPA estimated that overall natural uranium concentrations within the Ambrosia Lake mining district approached 0.1 mg/L (Ref. 7, p. 100). Selenium concentrations were generally less than 0.005 mg/L in the Lee wells; at the downstream Sandoval Ranch windmill, EID measured a selenium concentration of 0.018 mg/L in 1980 sample, which is thought to represent an upper limit estimate of pre-mining ground water selenium concentration. Natural ground water selenium concentrations may increase downstream from the Sandoval Ranch due to contribution from selenium-enriched sediments in Poison Canyon (Ref. 7, p. 100-101).

Ground water monitoring was conducted by EID between 1977 and 1982 from stations established in San Mateo Creek and Arroyo del Puerco to characterize the quality of natural ground waters and the impacts of uranium mining to these waters—specifically to characterize hydraulic and contaminant migration relationships between surface water and shallow ground water using monitor well clusters (Ref. 7, p. 21, 26). Available data indicate the presence of little alluvial ground water along the Arroyo del Puerto under pre-mining conditions (Ref. 7, p. 95). Mine dewatering throughout the GMD transformed ephemeral streams into perennial streams, increasing recharge to underlying alluvial aquifers, which raised water levels and shallow well yields up to 50 feet between the onset of dewatering in the 1950s and the late 1970s (Ref. 7, p. 66, 77). In March and early April 1980, when mine dewatering discharge to San Mateo Creek was insignificant, occasional flows of less than 1 cubic foot per second (cfs) caused the alluvial water table to rise slowly. In contrast, streamflow increase to 3 cfs in late April, which lasted nearly two weeks, caused the water table to rise within one week, peaking in mid-May more than one foot higher than the level in mid-April (Ref. 7, p. 74). When mine water discharges were reduced, alluvial water levels monitored below the confluence of Arroyo del Puerto and San Mateo Creek declined eight feet between March 1978 and March 1982 (Ref. 7, p. 77).

Investigation of the impacts to ground water in the vicinity of the Section 35 and 36 mines indicate that alluvial ground water in this area was sourced principally from the dewatering activities (Ref. 33, p. 23). At certain locations along San Mateo Creek, alluvial ground water chemistry more chemically resembled mine waters than natural waters. Mine water constituents that adsorb to sediments or that formed insoluble precipitates, such as ^{226}radium, were not found in alluvial ground water in significant concentrations (Ref. 7, p. 94; Ref. 33, p. 23). Other constituents that either do not interact with stream sediments or that form insoluble precipitates, such as uranium, selenium, or molybdenum, were found in ground waters in concentrations approaching those in undiluted mine waters (Ref. 7, p. 94).

As previously noted, streamflows recharge bedrock aquifers at subcrop and outcrop areas, or where the saturated alluvium overlies permeable bedrock with downward hydraulic gradient. At these localities, dewatering effluents also were introduced into these bedrock aquifers (Ref. 7, p. 77). Although mine water discharge to Arroyo del Puerto and San Mateo Creek are significant recharge sources to the Dakota and Morrison formations, local water level declines greater than 500 feet resulted from mine dewatering (Ref. 7, p. 77).

In general, test wells that have been affected by mine waters show concentrations of uranium, molybdenum, selenium, and gross alpha particle activity to be elevated above natural levels by 10 to 40 times (Ref. 7, p. 102). Chemical indicators in alluvial ground water to impacts from mine dewatering are inferred to include molybdenum concentrations greater than 0.03 mg/L, uranium concentrations greater than 0.03 mg/L upstream and 0.1 mg/L downstream of the confluence of San Mateo Creek with Arroyo del Puerto, selenium concentrations greater than 0.15 mg/L along San Mateo Creek upstream of the confluence, major changes in TDS concentrations and general chemistry with a distance of less than 3 miles, and significant declines in molybdenum, uranium, or selenium concentrations with increasing depth in the upper portion of the alluvial aquifer (Ref. 7, p.101). The presence of elevated selenium concentrations alone are not sufficient to demonstrate mine water effluent impacts (Ref. 7, p. 107).

Shallow ground water quality in the San Mateo Creek—Arroyo del Puerto drainage was transformed by dewatering effluents. One mile above the confluence of these watercourses, alluvial ground water at the Sandoval monitoring well cluster is indicative of sodium-sulfate-bicarbonate water chemistry, with a TDS concentration of about 650 mg/L. Downstream from the confluence, test wells produce ground water that ionically resembled Ambrosia Lake mining district mine waters (i.e., calcium-magnesium-sulfate type), with TDS over 2,100 mg/L (Ref. 7, p. 102). Mean uranium, molybdenum, and selenium concentrations at the Lee wells are below detectable concentrations of 0.005 to 0.01 mg/L; at the Sandoval well cluster, uranium and molybdenum concentrations are 10 to 20 times detectable limits, which was attributed to the effect of effluent infiltration. Below the confluence with the Arroyo del Puerto, uranium, molybdenum, and selenium concentrations were approximately 3 times higher than at the Sandoval well cluster. Uranium and molybdenum concentrations in the Otero wells are as much 7 times greater than projected natural levels in this portion of the San Mateo Creek drainage, indicating water quality degradation from mine water. Both uranium and molybdenum concentrations decrease with depth (Ref. 7, p. 105). Gross alpha particle activity also was significantly elevated along San Mateo Creek below the Lee wells, which reflects uranium concentrations almost exclusively (Ref. 7, p. 105).

Ground water restoration for the HMC Site has been ongoing in 4 aquifers (i.e., Alluvial, Upper Chinle, Middle Chinle, and Lower Chinle) since 1977 (Ref. 30, p. 1.1-1). Monitoring data from 2008 indicates that concentrations of one or more site contaminants of concern exceed site ground water standards (Ref. 9) within each of the impacted aquifers (Ref. 30, p. 1.1-3—1.1-7). One monitor well completed within the underlying San Andres aquifer upgradient of the HMC Site (Ref. 30, p. 8.0-4), which is not addressed by the HMC restoration (see Ref. 30, p. 1.1-1) has uranium concentrations exceeding federal (Ref. 10) and state (Ref. 14) drinking water standards.

For the June 2010 Phase 1 SI, a preliminary analysis of hydrochemical results from ground water sampling was provided (Ref. 3). The observations noted in the June 2010 report are:

- TDS concentrations increase generally from north to south within the sample set. Alluvial ground water samples typically had higher TDS concentrations than samples from bedrock aquifers. Areas of relatively elevated nitrate + nitrite concentrations were identified above the HMC Site and near the junction of state highways 605 and 509.
- Dissolved uranium concentrations average approximately 58 µg/L for the entire SI sample set.
- Analysis of the hydrochemical data indicates a positive correlation between dissolved uranium and selenium concentrations. The highest concentrations of uranium and selenium was found in presumed alluvial well located in the southern part of the area sampled for this SI, north (upgradient) of the HMC Site. Qualitative analysis suggests that the average concentrations of these analytes is higher than background concentrations.
- The highest activity values for ^{226}radium (2.90 pCi/l) and ^{228}radium (3.91 pCi/l) came from SMC-32, which is inferred to be completed in the Morrison Formation and was the closest well sampled downgradient in the alluvial aquifer below numerous legacy uranium mines and 2 uranium mills. In general, elevated radium concentrations occur in SI samples from inferred bedrock-completed

wells. However radium is generally considered to be an unreliable indicator of contamination originating from legacy uranium sites because it is relatively insoluble and has a strong tendency to adsorb onto mineral surfaces.

- Some alluvial ground water samples are preliminarily inferred to reflect impacts from mill raffinate, based upon observations of low uranium activity ratio ("AR") and high dissolved uranium concentration values, as well as comparison to a southwestern Colorado mill site investigation. Historically recharge to the alluvial aquifer within the San Mateo Creek basin included discharge from uranium mines and mills. Additional work is recommended to refine this analysis.

3.2.3 Ground Water Use

Ground water uses in the area include domestic, limited agricultural, and livestock watering, with the latter primarily derived from alluvial wells (Ref. 7, p. 14). Within the boundaries of the proposed Site, drinking water systems for the community of San Mateo (Water system no. NM3525733; Ref. 21), Tri-State Generating Station (Water system no. NM3595017; Ref. 53), ARCO (Anaconda) Coal Company—Bluewater Mill (Water system no. NM3591033; Ref. 54), and Homestake Mill (Water system no. NM3598133; Ref. 55) are listed with the NMED Drinking Water Bureau.

The water supply system for the community of San Mateo has two wells, of which only one is currently active. The system serves 192 people through 61 service connections (Ref. 21, p. 1). The supply wells of this system are completed in the Point Lookout Sandstone (Ref. 52, p. 2). NMED queried for non-coliform sample results available on-line; no occurrences of analyte concentrations that exceed Federal (Ref. 10, 11, and 12) or State (Ref. 14) drinking water standards were noted among the data available to include analysis for gross alpha – excluding radon and uranium, combined uranium, and combined radium (-226 & -228) (Ref. 21).

The Tri-State Generating Station system is an industrial/agricultural system that serves a population of 125 from 10 wells and a reservoir; 2 of the wells are shown to be inactive (Ref. 53, p. 1). NMED queried for non-coliform sample results available on-line; one sample collected between 2004 and 2007 exceeded the MCL for gross beta particle activity (Ref. 10; Ref. 53, p. 2).

The Bluewater Mill system served a population of 60 from 5 service connections that were sourced from 4 wells. The wells are currently shown to be inactive, and no analytical data for this system were available on-line (Ref. 54).

The Homestake Mill system served a population of 24 through 17 connections, and was sourced by one well. This well currently is shown to be inactive, and no analytical data for this system were available on-line (Ref. 55).

Three wells and a spring within a 4-mile radius of the Navajo-Brown Vandever Mine (see Figure 5) were noted during an inspection, with ground water levels in 1990 in two wells within 100 feet of an adit depth. At that time, these wells were a portion of the water supply to 430 people (Ref. 51).

Due to the complexity of the Site comprising numerous potential contaminant sources, ground water usage and potential impacts to wells located within Site target distance limits was not analyzed in accordance with Ref. 56, p. 61 (Ref. 57, p. 8). Figure 4 shows details of wells registered with the New Mexico Office of the State Engineer, and Table 3 summarizes well usage, within the San Mateo Creek basin.

Just outside of the Site boundaries, the communities of Grants (Water system no. NM3526133; Ref. 58) and Milan (Water system no. NM3525533; Ref. 59), and the Golden Acres Trailer Park (Water system no. NM3525133; Ref. 60) maintain regulated water supply systems. The Grants system serves a population of 8,892 through 3,211 service connections that are sourced from three wells, one of which is shown to be inactive (Ref. 58, p. 1). The wells are completed into basalt, alluvium, the San Andres Limestone, and the Glorieta Sandstone (Ref. 7, p. 14).

The Milan water system serves a population of 1,911 through 1,043 service connections that are sourced from 4 wells, one of which is shown to be inactive (Ref. 59, p. 1); these wells are completed into the San Andres Limestone (Ref. 7, p. 14).

The Golden Acres Trailer Park system serves a population of 81 through 23 service connections that is sourced from one well, which currently is shown to be inactive (Ref. 60).

The Mount Taylor Millworks water system is an industrial/agricultural system that is sourced from one well. The system serves a population of 65 (Ref. 61). NMED queried for non-coliform sample results available on-line; no occurrences of analyte concentrations that exceed Federal (Ref. 10, 11, 12) or State (Ref. 14) drinking water standards were noted among the data available (Ref. 61).

3.2.4 Ground Water Investigation Methods

On November 8 and 9, 2010, NMED personnel collected ground water samples from three private wells within the San Mateo Creek basin; and a private well outside of the basin, within the town of Cubero. Owners of the wells had contacted SOS in response to correspondence and other publicity from the U.S. EPA about the ongoing investigation of potential environmental impacts from legacy uranium sites within the Grants Mining District. The primary objective of this sampling task was to determine the quality of ground water to which receptors might be exposed, in comparison to federal and state drinking and ground water standards. A secondary objective was to collect hydrochemical data that could assist with the determination of whether contaminant releases from legacy uranium sites occurred from past site operations or are still occurring from wastes left on-site. Figure 5 presents a Google Earth map of the ground water sample locations. Table 4 summarizes available well construction information for the wells sampled.

In addition to samples from the four wells, NMED also collected a field blank (e.g., GMD-00) and one duplicate sample (e.g., GMD-03, duplicating GMD-02). All but one well (e.g., GMD-05) had operating submersible pumps and were used as sources of domestic drinking water. The well owner had drilled well GMD-04 to replace well GMD-05 due to its insufficient yield. The well for GMD-05 was not abandoned but it did not have an operable pump. NMED utilized a truck-mounted, submersible (Bennett) pump to collect the GMD-05 sample.

Wells were purged until field parameters stabilized prior to sample collection (Ref. 62). Field measurements of temperature, pH, electrical conductance, dissolved oxygen, and reduction-oxidation potential were conducted with a YSI 556 MPS meter (NMED #1 unit). Dissolved sample filtrate was obtained using a Geotech peristaltic pump and a 0.45 micron filter. Samples were analyzed by EPA Region 6 laboratory for concentrations of a specified suite of total and dissolved metals, cations, and anions (Ref. 63). The EPA Contract Laboratory Program (CLP), Region 6 Laboratory in Houston, TX performed the analysis for 25 metals and laboratory pH (Ref. 64 and Table 6). With the exception of mercury, CLP metals were analyzed according to method ILMO5.3 ICP/MS (Inductively Coupled Plasma/Mass Spectrometry). Mercury was analyzed according IMLO5.2 CVAAS (Cold Vapor Atomic Adsorption Spectrometry). Laboratory pH was measured according to EPA method 150.1. Additional analyses that were not available through EPA CLP were performed by Hall Environmental Laboratory of Albuquerque, NM and subcontractor labs (Ref. 65 and Table 7). The subcontract laboratories included Pace Analytical Services of Greensburg, PA for radiochemistry (gross alpha-beta, radium isotopes, and uranium isotopes) according to methods SM 7110C, EPA 900.0m, EPA 903.1, EPA 904.0, and HSL-300m. Isotech Laboratories Inc, of Champaign, IL performed the analysis of stable isotopes (oxygen and deuterium), and Beta Analytic, Inc. of Miami, FL performed radiocarbon dating (carbon-14).

For the Roca Honda Resources (RHR) sample number RH11-001A, the sample water from the Johnny M Mine north vent hole was collected by a bailer and analyzed by Energy Laboratories, Casper, WY (Ref. 66 and 67). This sample was not collected specifically for this SI, however the data is used as the collection location is relevant to other locations sampled for this investigation. The Chain of Custody form in the Energy Laboratories report identifies the sample number as RH11-001A, but email communication with the RHR consultant, HydroSciences, Inc., on June 23, 2011 indicated the north vent hole is well number 18 in their baseline data report (Ref. 66 and 68). Energy Laboratories utilized ICP/MS following either method number E200.7 or E200.8 for the total and dissolved metals analysis except for mercury which utilized method E254.1. Gross alpha and gross beta were measured according to method E900.0. ^{226}Radium was measured according to method E903.0 and ^{228}radium was measured according to method RA-05. Thorium-228 (^{228}Th), Thorium -230 (^{230}Th), and Thorium-232 (^{232}Th) were measured according to method 908.0.

GMD-01: The well from which this sample was collected is located near the town of Cubero, NM (Figure 5). The GMD-01 location is not in an area of known uranium mineralization. The owner of this well said that the well water has a sulfurous smell and leaves a white residue upon evaporation when used for watering a vegetable garden (Ref. 69). The GMD-01 well application document indicates the well was to be completed to a depth of 600 ft, but the final well record submitted on March 12, 2011 indicates the well was completed to a depth of 126 ft in alluvial fill (Ref. 70). The depth to static water level was 22 ft according to the well record.

Figure 6 presents a composite stratigraphic column for the Ambrosia Lake area (Ref. 52) to illustrate the sequence of hydrostratigraphic units discussed below. Sample GMD-02 and associated duplicate sample GMD-03 were collected from a well that was drilled in March 2009. Although the well is documented to have been completed in the San Andres aquifer which was encountered between 520 and 600 feet (80 ft screen section) below ground surface (bgs), the well is constructed with annular gravel pack above the screen sand pack up to a depth of 200 ft bgs. According to the well record, ground water was first reported during drilling at 360 ft bgs (Ref. 70). Since it was observed that ground water is present above the depth of the screen section, it may be possible that ground water from the San Andres aquifer is commingled with water from the overlying aquifers (Chinle?) through the gravel pack. Interpretation of the drilling log indicates the clay-like, probable hydrostratigraphic unit beginning at 75 ft deep and ending at 540 ft deep is the Chinle Formation or eroded Chinle fill in erosional surfaces (channels?) of the underlying unit. At 540 ft deep, the hydrostratigraphic unit appears to change to what is likely the Glorieta Sandstone and the San Andres limestone unit. The well record describes the completed well as shallow (unconfined) but due to the thick sequence (Chinle?) of red clay (285 ft thick) above the production zone of 520-600 ft deep, and the depth to the static water level at 145 ft: the well is more likely to be in a confined, artesian hydrostratigraphic unit. Unfortunately, due to the construction of the well, the water produced at this location is possibly a mixture of Chinle and San Andres water. The regional ground water flow direction in the San Andres formation is towards the east-southeast (Ref. 3). The former Anaconda Company Bluewater uranium mill site is located in the upgradient direction of this well (Ref. 44 Figure 3); however, the well is also located down gradient from and in the SMC alluvial channel that conveyed mine and mill discharge water from the upper SMC basin.

Figure 7 presents the geologic log from the Johnny M Mine illustrating the sequence and depth of stratigraphic units at the mine location (Ref. 71). GMD-04 was collected from a well that is reported to be completed to a depth of 940 ft with a static water level at 625 ft deep (Ref. 70). The well record log describes the completed well as shallow (unconfined), but due to the total well depth; thick sequence of black shale (590 ft, probably Mancos Shale) above the production zone of 840-860 ft; and the depth to the static water level at 625 ft: the well is likely in a confined, artesian hydrostratigraphic unit (Cretaceous Dakota Sandstone, and Jurassic Morrison Formation, Westwater Canyon member or Jmw?).

GMD-05 was collected from a well slightly north of the GMD-04 location from a well that was completed to a depth of 715 ft and has a depth to static water level of 624 ft. The principal water bearing strata is described at a depth of 620 to 680 ft. The hydrostratigraphic unit at this location and depth is possibly the Cretaceous Mancos Shale (Km).

Two additional sets of ground water sample laboratory results were acquired to enhance the geochemical interpretation of the hydrogeology in the area of the GMD-04 well and an inactive, nearby uranium mine called the Johnny M Mine. Roca Honda Resources conducted ground water sampling in this area that included (Ref.72 and 67): the GMD-04 well (sampled September 23, 2010 as RHR-143); and the Johnny M Mine North Vent Hole (sampled March 14, 2011 as RH11-001A). Figure 5 indicates the location of the Johnny M Mine as a magenta square east of the GMD-04 and GMD-05 sample locations. The Johnny M

Mine North Vent Hole is documented as an important historical feature in the NMED Discharge Permit No. 20 file (DP-20) because it is the location where mill tailings sand backfill were staged and then emplaced by slurry line into the underground mined areas and stopes to keep the ore host formation from collapsing (Ref. 73). The depth of the ore in the Poison Canyon Tongue of the Brushy Basin Member of the Morrison Formation is approximately 1,300 to 1,400 ft bgs (Ref. 74). The North Vent Hole is a shaft that is covered by a thick steel plate at the surface, but an open pipe is present in the plate that provides access to the open shaft and into the original working levels of the mine (Ref. 74). A bailer was used to provide a grab sample of the water in the shaft (RH11-001A).

The RHR-143 sample parameter concentrations are very similar to the GMD-04 sample parameter concentrations with the exception of gross alpha and gross beta (Table 9). Many of the metal concentrations in the RHR-143 sample are reported as ND non-detect below a certain reporting limit. Overall, the major ion concentrations of GMD-04 and RHR-143 are very similar to each other, and the radiochemical parameters of Ra-226, Ra-228, and U total are almost identical. The RHR-143 sample results are not included in the geochemical interpretation since it is almost a match to the GMD-04 sample results.

The RH11-001A sample parameter concentrations represent ground water from a unique location in the hydrostratigraphy of the Johnny M Mine area. It is assumed that the water in the bottom of the shaft at the North Vent Hole is representative of the Jurassic Morrison Formation, Brushy Basin Member (Jmb) hydrostratigraphic unit. This is the geologic unit containing the uranium mineralization that was mined, stoped, and backfilled with tailings sand slurry. During active mining the Jmw elevation was below the top of the saturated zone elevation, so it had to be dewatered in order to enable mining to extract the ore. It is assumed that the ground water in the shaft of the North Vent Hole is from the resaturation of the Jmw unit since dewatering ceased in the early 1980s and up through 2010. It is also possible that the shaft water contains seepage from the overlying Dakota Sandstone since it could also discharge into the mine shafts due to the loss of pressure in the Westwater.

3.2.5 Ground Water Investigation Results

Analytical results were compared to applicable federal drinking water standards for Maximum Contaminant Levels (MCLs) which are enforceable standards for public water supply sources; National Secondary Drinking Water Regulations (NSDWRs) which are non-enforceable standards for public water supplies (Ref. 10, 11, 12, and 13); and state ground water standards (Ref. 14 and 15). Table 8 presents a summary of the sample location field data information and laboratory chemical results for dissolved parameters and select isotopes. The information in Table 8 is from the EPA CLP report (Ref. 75); the Hall Environmental Laboratory report (Ref. 76); the RHR BDR (Ref.72); and RHR Energy Laboratories report (Ref. 77). Table 9 presents a summary of water sample parameter exceedances of applicable federal and state drinking water and other state standards.

Sample GMD-01 had no exceedances of respective standards for reported analyte concentrations.

GMD-02/GMD-03: Samples exceed the enforceable MCL for gross alpha concentration (15 pCi/l: Ref. 10) since the sample concentrations are 34.1 ± 7.43 pCi/l (GMD-02) and 22.8 ± 5.34 pCi/l (GMD-03), respectively. Samples exceed the non-enforceable NSDWR standard for TDS (500 mg/l), and the NMWQCC standard for TDS (1,000 mg/l). The uranium concentrations are 29.2 and 27.9 ug/l, respectively, which is very close to the EPA MCL and NMWQCC standard of 30 ug/l (Ref. 10 and 15).

GMD-04: 17.3 pCi/l (total) exceeds the enforceable MCL for gross alpha concentration (15 pCi/l); 0.068 mg/l (total) and 0.0657 mg/l (dissolved) exceed the non-enforceable NSDWR standard for manganese (0.050 mg/l); and 709 mg/l TDS exceeds the non-enforceable NSDWR standard for TDS (500 mg/l).

GMD-05: 1500 mg/l (total) exceeds the non-enforceable NSDWR standard for chloride (250 mg/l) and 3070 mg/l TDS exceeds the non-enforceable NSDWR standard for TDS (500 mg/l) and the NMWQCC standard for TDS (1,000 mg/l).

RH11-001A: 0.012 mg/l exceeds the enforceable MCL for arsenic (0.010 mg/l); 263 pCi/l (total) exceeds the enforceable MCL for gross alpha concentration (15 pCi/l); 68.0 pCi/l (total) exceeds the enforceable MCL for gross beta concentration (50 pCi/l); 79 pCi/l (total) exceeds the MCL for radium-226; 0.174 mg/l (dissolved) exceeds the MCL for uranium (0.030 mg//l);; 584 mg/l exceeds the NSDWR for TDS (500 mg/l); 80.5 pCi/l (total) exceeds the NMWQCC standard for combined Ra226 + Ra228 (50 piC/l).

3.2.6 Sample analysis and discussion

Following on and drawing largely from the work on the 2008 Bluewater (BW) and 2009 San Mateo Creek (SMC) sample results (Ref. 3), a brief geochemical interpretation of the sample results is provided here with some discussion about the SMC ground water system overall. As noted above, Table 8 presents a summary of the data values describing the sample number, field parameters, dissolved chemical values, and isotopic results for the GMD (6 each) and RHR (2 each) sample sets. It is important to note that the GMD samples were collected primarily to check the water quality for compliance with federal and state standards. The RHR samples were collected to support a baseline data report for the permitting of a new uranium mine. With the exception of the three water samples from the T13N, R8W, Section 18 area, the other two samples from this area by themselves do not provide much new hydrogeologic information.

GMD-01 sample results are from an area that has not been exploited for economic deposits of uranium. GMD-02 (GMD-03 is a duplicate of GMD-02) is from a well that is in a location bounded by wells that were sampled in 2008 and 2009 by NMED. GMD-04 (same as RHR-143) and GMD-05 are from locations that are in close proximity to the Johnny M Mine. RH11-001A is a water sample collected through the Johnny M Mine north vent hole-shaft. After the field blank, duplicate, and repeat samples are removed from the data set, five samples are left for interpretation. The five samples represent three distinct areas of ground water: Cubero (1); lower San Mateo Creek (1); and Johnny M Mine area (3). Calculation of average values for the set of samples is not performed because: the number of samples is too small; the samples are from different hydrostratigraphic units; and the samples come from separate geographic locations.

The five sample results are evaluated as a group based on: major ions; trace metals; radiochemistry; stable isotopes; and radiocarbon (C-14). Only the GMD set of samples were analyzed for stable isotopes and C-14. The total dissolved solids (TDS) concentration ranged from a low of 291 mg/l (GMD-01) and a high of 3,070 mg/l (GMD-05). Three of the samples (GMD-01, GMD-04/RHR-143, and RH11-0019A) had a TDS of less than 1,000 mg/l and are characterized as fresh water (Ref. 78). One of the samples (GMD-02) has a TDS concentration slightly above 1,000 mg/l and is characterized as slightly brackish. One sample has a TDS concentration around 3,000 mg/l and is characterized as brackish. The pH in the sample group ranged from 7.06 to 8.39 (near neutral to slightly alkaline). The group dominant cations in the order of concentration were Na>>Ca>>Mg>>K. The group dominant anions in the order of concentration were SO_4>> HCO_3 >>Cl. GMD-05 chemistry is unique compared to the other samples because it is highly concentrated in two major ions (Na and Cl) which also contribute to the highest sample TDS concentration (3,070 mg/l) of the group.

Figure 8 is an x-y chart of the major ion concentrations for the set of six GMD and one RHR samples (RH11-001A only). The line for GMD-01 is visible only for the SO_4 , HCO_3 , and TDS concentrations indicating it is purified water and suitable for a field blank. The line for GMD-02/GMD-03 is visible only as one line that is the second highest concentration for Na, the highest concentration for SO_4, and the second highest concentration for HCO_3 and TDS. The line for GMD-04 is hardly visible for the first five major ions along the x axis, but it is visible for SO_4, HCO_3 , and TDS. The line for GMD-05 is the highest in concentrations of Na, Cl, HCO_3 , and TDS. The line for RH11-001A is similar to GMD-04 (SO_4 , HCO_3 , and TDS).

Based on the group of seven samples except for the field blank (GMD-00) that includes the five GMD samples and two RHR samples, the total number of metal concentrations below the reporting limit include: Ag (7); Al (7); As (3); Ba (3); Be (6); Cd (7); Co (7); Cr (7); Cu (7); Fe (5); Mg (7); Mn (2); Mo (3); Ni (7); NO_3+NO_2 (7); Pb (7); Sb (7); Se (3); Tl (7); U (2); V (5); and Zn (5). The large number of trace elements with reported values less than the reporting limits results in actual measured values not available for interpretation. It is assumed based on the chemical results from this sampling that many trace metals are not present in ground water at levels that can be measured using standard laboratory methods, or they are entirely absent in the ground water. For some specific calculations and graphical plots in this report, a value that is 50% of the reporting limit is used when sample chemical results are reported as less than reporting limits. Nine trace metal concentrations (As, Ba, Fe, Mn, Mo, Se, V, Zn, and U) were used to create the x-y chart in Figure 9.

Figure 9 indicates five samples are elevated in concentrations of Ba, Fe, Mn, Mo, Zn and U. GMD-01 contains the highest concentration of Fe. GMD-04 contains elevated concentrations of Ba, Fe, and Mn. GMD-05 contains the highest concentration of Ba. Sample RH11-001A is significantly elevated in Mo and U. It is believed that the high Zn concentration in GMD-04 is probably from the newly installed galvanized pipe in the well and supply line since it was drilled and fitted with a new pump in 2009.

Figure 10 is a trilinear diagram with the BW, SMC, GMD, and RHR samples plotted together for an overall comparison of water types (Ref. 79). GMD-01 is a Ca- HCO_3 water type. GMD-02/GMD-03 is a Na+K-SO_4 water type, very similar in chemical composition to BW-32 which is a well and sample located southwest of GMD-02. As noted in Table 5 and discussed previously, sample GMD-02 is from a well that was drilled to a depth of 635 ft and has a production zone from 520-660 ft. Since the well was constructed with an excessively long gravel pack interval that possibly connects more than one water-bearing zone, the Na- SO_4 water type of GMD-02 is suspect. GMD-02 should have a water composition that plots in the large blue area with other samples from the San Andres-Glorieta (SAG) aquifer that contain more concentrations of Ca, Mg, and HCO_3 over Na and SO_4. Since GMD-02 plots next to BW-32, an 864 ft. deep well, it is suggested that these two samples are representative of the same ground water in this part of the SMC basin. Since GMD-02 and BW-32 are deep wells supposedly completed in the SAG aquifer, they should have more of a Cam- HCO_3 geochemical composition. The higher concentration of Na and SO_4 in these two samples suggests the water from these wells is geochemically similar to alluvial aquifer water (yellow areas in Figure 10). It is possible that the wells at these locations are drawing water from other zones creating a shift or mix in composition that makes the water more similar to alluvial water than a deep bedrock, carbonate and sandstone aquifer. It is suggested that the well construction and/or well seals are enabling a mixture of water to be produced at these two sample locations.

Figure 10 indicates that GMD-04 is a mixed ion water type because it plots in the center of the diamond. GMD-04 does plot very close to the lower area of Jmw samples which are also a mixed ion water type. GMD-05 is a Na-Cl water type and it plots in the far right side of the diamond in an area of alluvial water type. RH11-001A, the Johnny M Mine north vent hole sample plots in the center of the diamond near the GMD-04 sample, and it is a mixed ion water type (Ca+Mg- HCO_3 + SO_4). RH11-001A and GMD-04 are assumed to represent water from the Jmw unit. The unique water type and well depth information for GMD-05 suggests the hydrostratigraphic unit is Km (Cretaceous Mancos Shale). The high dissolved solids content of primarily Na and Cl ions suggests the ground water from this hydrostratigraphic unit is a more chemically evolved brackish water.

The effects of uranium mining on ground water in the Ambrosia Lake area was evaluated by Kelly, Link, and Schipper in 1979 (Ref. 79). This study looked at the change in water quality over time of the Jmw hydrostratigraphic unit. Due to the loss of hydraulic head in the Morrison Formation because it had to be dewatered in order to mine, the result is the migration of ground water from overlying units like the Cretaceous Dakota sandstone (Kd). Prior to dewatering and mining, the Jmw unit contained water that was primarily a Na+K-HCO_3 water type. After the hydraulic head in the Jmw unit decreased and mining ceased, water from the Dakota sandstone flowed downward into the Jmw unit and mixed resulting in a water that is more concentrated in SO_4 ions.

Figure 11 is a stable isotope plot of the isotopic concentration of oxygen-18 and deuterium in the BW, SMC, and GMD samples. Figure 11 combines the data presented in Figure 21 and 37 of the NMED 2010 report and includes the GMD samples (Ref. 3). In Figure 11 the samples have been further categorized into sub sets based on their geographic area in order to provide more opportunity to compare samples for differences and similarities. In general, the GMD samples plot across the spectrum of isotope values.

GMD-05 plots toward the lightest samples which are assumed to result from a source of isotopically lighter water such as recharge from snow melt which tends to be the source in higher altitude locations (Zuni Plateau, upper Ambrosia Lake). GMD-00, the field blank, is from a water vendor in Santa Fe, NM which is assumed to be San Juan Chama Project water. GMD-00 appears to suggest an isotopically heavier water perhaps from purification and/or evaporation. GMD-02/GMD-03 and GMD-04 plot in the center of the chart and are isotopically similar in composition. GMD-01 is isotopically lighter in δ18O than GMD-02 and GMD-04 by about 1.0 per mile. Figure 7 shows that the majority of BW SAG aquifer samples plot in one group that is overlapped by SMC, 605 & 509 junction, and wells northeast of Homestake (Qal) samples. The Bluewater Mill Site SAG samples plot away from the Global Meteoric Water Line in a manner that suggests the water from these wells appears to be more evaporated than the main group of BW SAG samples.

Carbon-14

As an experiment to see if the radioactive isotope of carbon (Carbon-14 or ^{14}C) could reveal new information about the ground water flow system in the area, the GMD water samples were analyzed for ^{14}C. The element carbon (C) has two stable isotopes (^{12}C and ^{13}C) and one radioactive isotope (^{14}C). ^{14}C has a half-live of approximately 5,730 years and it is the only radioisotope found in nature where trace amounts are formed in the atmosphere by the process of nitrogen transmutation from bombardment with cosmic rays (Ref. 78). Prior to the above ground thermonuclear tests that introduced radioactive carbon into the atmosphere, the ^{14}C content was assumed to be fairly constant during the past 7,000 years. The ^{14}C generated in the atmosphere is carried down to the earth's surface by precipitation, and it becomes incorporated into the biomass or transported into parts of the hydrologic cycle such as the oceans, lakes, rivers, and ground water (Ref. 80). ^{14}C undergoes natural decay to ^{14}N so that once it is isolated from the atmosphere, the amount of ^{14}C decreases with time according to the equation

$$(^{14}C)_t = (^{14}C)_o e^{-kt}$$

Where $(^{14}C)_t$ is the amount present at time t, $(^{14}C)_o$ is the amount present at $t = 0$, and k is the decay constant, which is related to the half-life $T_{1/2}$ by the equation

$$T_{1/2} = \ln 2 / k$$

To determine the time since a water was last in contact with the atmosphere, it is necessary to know (^{14}C). Studies of ^{14}C content of tree rings indicate that this concentration of ^{14}C has varied slightly during the past 7,000 years, and there is no accurate way to determine it prior to this time. Other evidence suggests that there have been major shifts in the ^{14}C content in the atmosphere during the past several tens of thousands of years (Ref. 80). The law of radioactive decay and half life expressed by the equations above can be used in conjunction with the measurement of ^{14}C content in ground water as a guide to the *age* of the ground water. The term *age* refers to the period of time that has elapsed since the water moved deep enough into the saturated zone to be isolated from the earth's atmosphere.

There are some complications in the behavior of ^{14}C during recharge, so that the absolute age of the ground water cannot be determined reliably (Ref. 80). One complication is that dissolution of carbonate minerals or oxidation of organic matter within the aquifer may add old or dead carbon to the water, giving an erroneous age date that is older than actual. Typically most carbonate rocks that contain calcite and dolomite are much older than 50,000 years, devoid of ^{14}C, and considered dead carbon. Another complication is mixing different ages of ground water. Utilization of ^{14}C age dates for ground water requires an assumption that the extent of mixing is insignificant. In summary, there are assumptions and adjustments that must be made in order to determine the *apparent* age of ground water using ^{14}C dating, however, this technique is useful to determine if the water is less than a few thousand years old (young water) or greater than a few tens of thousands of years old (old water). This type of information is useful in the interpretation of a ground water system at specific locations along a regional flow path with numerous data points and in specific hydrostratigraphic units where the hydrogeologic information and the number of wells are limited.

In correlation with the measurement of ^{14}C, the concentration of the less abundant but stable isotope ^{13}C is also measured as another means of tracking the evolution of carbonate in the system (Ref. 81). The evolution of dissolved inorganic carbon in ground water begins with atmospheric CO_2 that has a $\delta^{13}C$ concentration of -7 o/oo. Biogeochemical reactions in the ground water system can be examined by the differences in the $\delta^{13}C$ content. For example, photosynthetic uptake of CO_2 by plants can deplete the $\delta^{13}C$ content, whereas, dissolution of carbonate minerals can cause $\delta^{13}C$ to increase. If the ground water system is an open system or unconfined aquifer then the ^{14}C content is continually replenished and maintained near 100 percent modern carbon (pmc; Ref. 81). In a closed system or confined aquifer, the original ^{14}C content is fixed and radioactive decay reduces the concentration such that the longer ground water resides in isolation from soil CO_2, the lower the ^{14}C activity which means the apparent age of the water is older (Ref. 81).

A search of the World Wide Web for ground water investigations in NM using ^{14}C isotopes provided two informative references: an isotopic-numerical ground water flow model of the San Juan Basin (Ref. 82); and a geochemical characterization of ground water flow in the Middle Rio Grande Basin (Ref. 81). These investigations border on or include part of the Grants Mining District so it is assumed that the range of ^{14}C ground water ages in these investigations may be reasonable for the SMC basin, qualitatively speaking. The ^{14}C ground water age ranges from modern to over 30,000 years. The ^{14}C data is presented in Table 6 for samples GMD-00, -01, -02, -03, -04, and -05. The ^{14}C data ranges from an apparent age of 890 years (+/– 40 years Before Present, BP) in GMD-01 to 28,170 years (+/- 130 years BP) in GMD-05. GMD-00, the field blank has a ^{14}C apparent age of 5,150 years +/- 40 BP, and it suggests that the water source has an apparent age of around 5,000 years old.

GMD-01 is from an unconfined alluvial aquifer in the Cubero, NM area, and it suggests that this ground water is relative young and less than 1,000 years old. GMD-01 is in a location that is on the western margin of an unnamed alluvial drainage, and in an area where bedrock is exposed at the surface (Ref. 81). The young age of the water suggests that the ground water at this location does not have a very long residence time, and it has a high content of modern carbon close to that the atmosphere and recent recharge. GMD-01 likely received recharge fairly recently (by geologic time scale) possibly by flow in the upgradient alluvial channel or by infiltration of precipitation in direct contact with bedrock exposed at the surface. Since the GMD-01 well is completed in a shallow and unconfined aquifer, it is likely influenced more by soil zone CO_2 rich in modern carbon than by dissolution of carbonate minerals.

GMD-02/03 has an apparent ^{14}C age of 8,150 years +/- 40 BP. As discussed in the 2010 NMED geochemical evaluation report for the SMC area, the recharge area for the San Andres Limestone-Glorieta Sandstone (SAG) aquifer is the Zuni Plateau to the southwest. This apparent age is fraught with uncertainty because it may be from a source that is a mixture of water from more than one aquifer.

3.3 Surface Water Pathway

The surface water pathway assesses the threat to human health and the environment by determining whether hazardous substances are likely to have been released to surface water; and whether any receptors (intakes supplying drinking water, fisheries, sensitive environments) are likely to be exposed to a hazardous substance as a result of a release.

3.3.1 Hydrology

Most streams are ephemeral within the GMD. Peak runoff from heavy late-summer thunderstorms and lesser flows from snow melt in late winter and early spring carry high sediment loads (Ref. 7, p. 13). San Mateo Creek has flowed continuously since construction of San Mateo Reservoir near the community of San Mateo; however this flow usually is ephemeral within 1 mile below San Mateo (Ref. 7, p. 13). Average stream bed loss along San Mateo Creek is approximately 0.72 cubic meters per minute per kilometer (Ref. 7, p. 72). Infiltration rate in the Ambrosia Lake mining district was calculated to be 7.54 cubic meters per minute (Ref. 7, p. 74).

3.3.2 Surface Water Quality

Ephemeral perennial streamflows that were created from mine dewatering were important livestock water supplies (Ref. 7, p. 14). Surface water in the GMD, both from natural or mining-impacted sources, was used for livestock watering. Only artificially-maintained perennial streams were used for irrigation. No domestic use of surface water has been documented (Ref. 7, p. 111).

3.3.3 Surface Water Investigation

Natural runoff has average suspended sediment concentrations greater than 30,000 mg/L. Flow within San Mateo Creek typically has suspended sediment concentrations less than 400 mg/L. TDS concentrations in flow within Arroyo del Puerto that was influenced by mine discharge were 1,500 to 2,000 mg/L; occasionally natural waters diluted these concentrations to less than 1,000 mg/L (Ref. 7, p. 84).

In natural runoff, contaminants are generally associated with suspended sediment and precipitates (Ref. 7, p. 87). Natural runoff has median concentrations of total molybdenum and selenium of less than 0.01 and 0.03 mg/L respectively (Ref. 7, p. 87). Median total barium concentrations in natural runoff is 7.7 mg/L (Ref. 7, p. 88). As much of 99% of the gross alpha and gross beta particle activities in natural runoff are associated with precipitates and suspended sediment. Dissolved gross alpha levels are generally less than 20 picocuries per liter (pCi/L), with dissolved uranium accounting for more than 80 percent. Total ^{226}radium concentration in natural runoff often exceeds 15 pCi/L, but usually has less than 2 pCi/L of dissolved ^{226}radium. Natural runoff typically has concentrations of total ^{210}lead and ^{210}polonium between 40 and 90 pCi/L respectively (Ref. 7, p. 90).

Surface water monitoring was conducted by EID between 1977 and 1982 from stations established in San Mateo Creek and Arroyo del Puerto to characterize the quality of natural surface waters and the impacts of uranium mining to these waters—specifically to characterize hydraulic and contaminant migration relationships between surface water and shallow ground water. Monitoring locations included flow from both uranium mine dewatering effluents and natural perennial flow (Ref. 7, p. 21). Additionally, single-stage samplers were installed within ephemeral watercourses above and below mine waste piles to characterize runoff; additionally grab samples collected during runoff events above and below waste piles (Ref. 7, p. 32).

EID investigators concluded that TDS concentrations in perennial stream flows throughout the GMD varied between less than 200 to greater than 1,500 mg/L, with the lowest TDS values found in the perennial flow of San Mateo Creek (Ref. 7, p. 43-44). Dissolved trace element and radionuclide concentrations in both perennial and ephemeral flows throughout the GMD are very low, due to the low solubility of these materials and the prevailing neutral to slightly alkaline nature of the flows (Ref. 7, p. 45). Suspended sediment concentration in the San Mateo perennial flow had a log mean concentration of 10 mg/L, while ephemeral flow in the same streamcourse had a log mean concentration of 8,100 mg/L (Ref. 7, p. 47). Total trace element and radionuclide concentrations in natural runoff generally were dependent upon sample sediment amounts. Molybdenum was virtually absent from runoff (Ref. 7, p. 48). In turbid waters, gross alpha particle activity among 5 samples ranged from 33 pCi/L to 2,100 pCi/L, with a median concentration of 1,200 pCi/L. Gross beta particle activity among 4 samples ranged from 546 pCi/L to 2,000 pCi/L, with a median concentration of 1,060 pCi/L (Ref. 7, p. 48). The majority of ^{226}radium and ^{210}lead concentrations found in turbid water samples were bound to sediments (Ref. 7, p. 51). Maximum gross alpha particle activity exceeded maximum natural runoff activity by 200 times. Maximum levels of natural uranium and ^{226}radium, which are 2 major alpha particle emitters, exceed natural maximum runoff levels by over 100 times. Gross beta particle activity, especially from ^{210}lead, also far exceed natural runoff levels (Ref. 7, p. 57).

As noted previously, runoff sampling below uranium mine waste piles indicated that sediment concentrations were comparable to natural sediment concentrations.

3.4 Soil Exposure Pathway

The soil exposure pathway assesses the threat to human health and the environment by direct contact with hazardous substances and areas of suspected contamination. This pathway addresses any material containing hazardous substances that is on or within 2 feet of the surface and not capped by an impermeable cover.

3.4.1 Soil Exposure Pathway Investigation Methods

An ongoing EPA risk assessment for the Homestake site will investigate the potential for contaminated soil source to impact human health through media including plant and animal uptake, as well as by direct contact (Ref. 83). The need to further characterize this pathway will be dependent upon waste characteristics at individual mine and mill sites within the Site.

3.4.2 Potentially Exposed Receptors

An ongoing EPA risk assessment for the Homestake site will investigate the potential for contaminated soil source to impact human health through media including plant and animal uptake, as well as by direct contact (Ref. 84). The need to further characterize this pathway will be dependent upon waste characteristics at individual mine and mill sites within the Site.

3.4.3 Soil Investigation Results

Pond and stream sediment analytical and soils analytical data collected from the Poison Canyon Mining District are shown in Table 2. These data, in comparison to background samples collected within the same area, indicate elevated concentrations of ^{238}uranium, ^{234}uranium, ^{230}thorium, ^{226}radium, lead^{210}, vanadium, lead, and copper in one or more of these samples in comparison to concentrations determined in samples that were collected to characterize background (Ref. 50). Selenium is locally enriched in soils and plants in the Poison Canyon area (cited in Ref. 7, p. 100).

The investigation of soil impacts from dewatering activities associated with the Section 35 and 36 mines indicate that ^{226}radium and uranium concentrations in soil, while decreasing with increasing depth, exceed assumed background concentrations. Exclusive of arsenic, total metals concentrations are below New Mexico Environment Department (NMED) Soil Screening Levels, and leachable metals concentrations, excluding selenium, and leachable major ions and TDS are below New Mexico Water Quality Control Commission (WQCC) standards (Ref. 33, p. 7-8).

3.5 Air Pathway

The air pathway assesses the threat to human health and the environment by determining whether hazardous substances are likely to have been released to the air; and whether any receptors (human population and sensitive environments) are likely to be exposed to hazardous substances as a result of a release. The need to characterize this pathway will be dependent upon waste characteristics at, and population densities near, individual mine and mill sites within the Site.

4.0 Summary and Conclusions

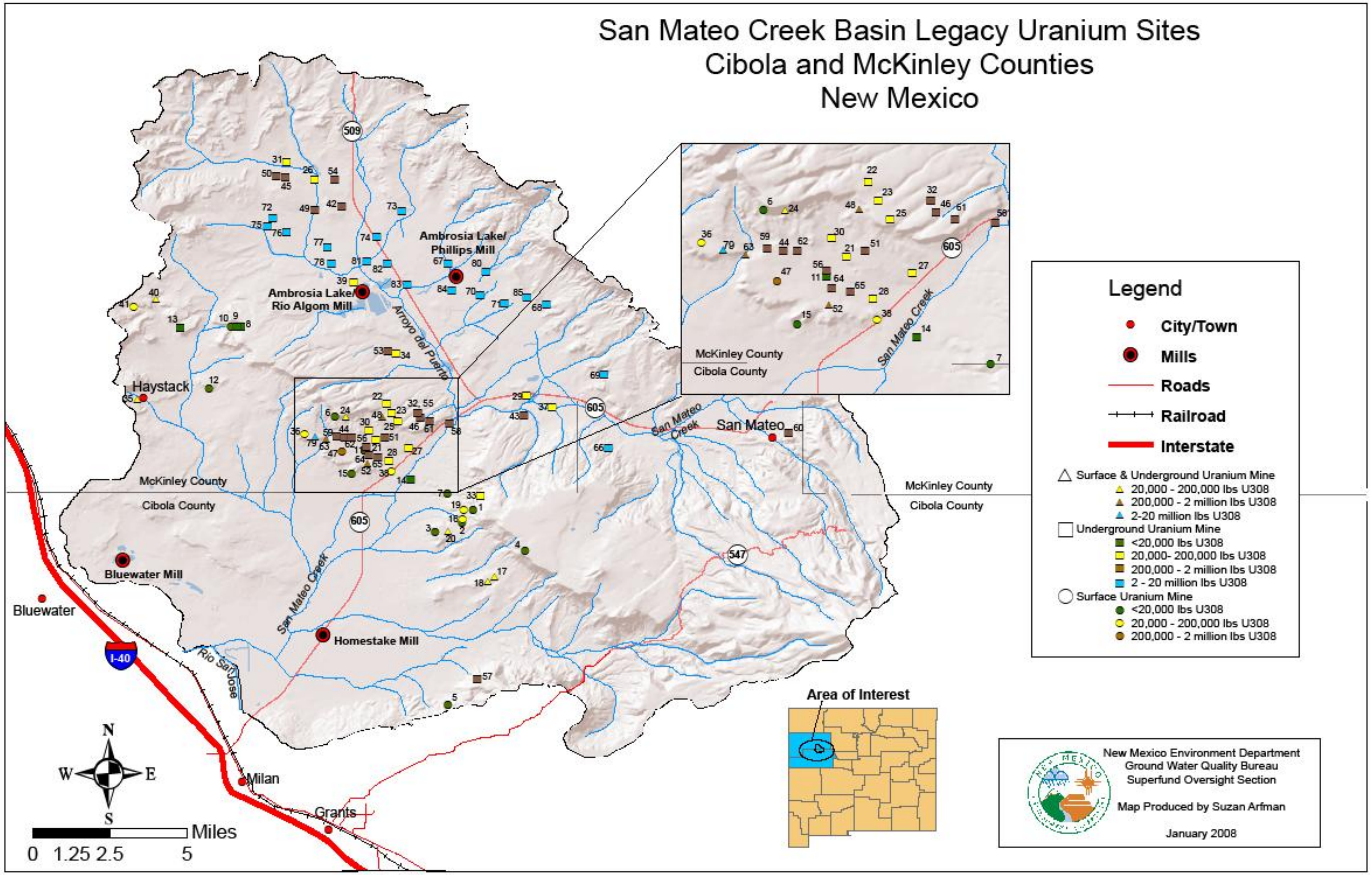
The primary objective of the GMD SI P2 was to collect ground water samples and evaluate ground water by comparison of analyte concentrations to federal and state drinking water standards, and identify potential receptors to ground water contamination. As indicated in Table 4 and 5, drinking water parameters were exceeded for: gross alpha (4); ^{226}Ra+^{228}Ra (2); uranium (1); SO_4 (4); TDS at 500 mg/l (5); Cl (1); Mn (1); and TDS at 1,000 mg/l (3). The sample results and well record data were also evaluated as part of the ongoing hydrogeologic investigation of the SMC ground water system that was described in the 2010 SI report (Ref. 3). The sample group general water chemistry ranges in TDS concentration from fresh water to brackish water and ranges in pH from near neutral to slightly alkaline. The sample group dominant cation order is Na>>Ca>>Mg>>K; and the dominant anion order is

SO_4>>HCO_3>>Cl. A large number of trace elements reported concentrations below the laboratory reporting limit with the exception of As, Ba, Fe, Mn, Mo, Se, V, Zn, and U. Sample group major ion water types ranged from Ca-HCO_3 to Na+K-SO_4 to Na-Cl to mixed ion. Stable isotope concentrations in the sample group are unremarkable and did not reveal any new information about the ground water system or potential sources of contamination. ^{14}C concentrations in the sample group suggests that ground water ranges in apparent age from young to old depending on the assumed location in the ground water flow path and the hydrostratigraphic unit(s) for the well screen zone(s). Based on well record information and the geochemistry of the samples collected for this Phase 2 SI, ground water analytical results do not indicate the presence of contamination involving anthropogenic sources. However, the grab water sample collected from the Johnny M Mine north vent hole (RH11-001A) strongly suggests the presence of contamination involving anthropogenic sources or activities. The water sample from the Johnny M Mine north vent hole suggests the ground water in the vent shaft and adjacent area is contaminated with radionuclides and daughter products from the U series.

Ground water sampling of previously un-sampled wells in the SMC basin should continue where new information is to be gained. Geochemical analysis of new water samples for the large suite of parameters should continue and include select isotopes of oxygen, deuterium, sulfur, carbon, and uranium where possible. Further analysis of the SMC laboratory data set should continue to employ ion concentration and ratio plots for comparison, group, and trend indications based on similar or dissimilar geochemical, radiochemical, hydrostratigraphic, and/or geographic characteristics. Utilization of the program, EnviroInsite, may provide new opportunities to present data in charts and maps that illustrate characteristics of the SMC ground water system not yet realized with less sophisticated methods. The ground water data provided by Roca Honda Resources as part of the BDR for a potential new uranium mine should be incorporated into the SMC data base and evaluated using conventional methods and EnviroInsite. New data from ongoing and pending investigations at the Bluewater, Homestake, Rio Algom, and Phillips mill sites should be incorporated into the SMC data base. The ground water system(s) in the vicinity of the Johnny M Mine will require further characterization and provide new data about the nature and extent of potential contamination.

The investigation of ground water in the SMC area is reaching a point where almost all of the existing wells and water sources have been sampled and analyzed for a large suite of geochemical and radiochemical parameters. Although resampling of select ground water locations for various stable and radioactive isotopes is prudent and it provides more chemical information, the SMC investigation is reaching the point where new data points are necessary. The existing wells in the SMC area are inadequate to provide much new information because their location is incorrect and/or the construction of the well screen zone and seals is incorrect or suspect leading to uncertainty and unreliability in the data. New monitoring wells are needed that are sited in key locations and constructed to provide water and information from specific hydrostratigraphic units, and near important geologic structures legacy mine and mill sites.

Figure 1: Mines and mill locations



Notes:

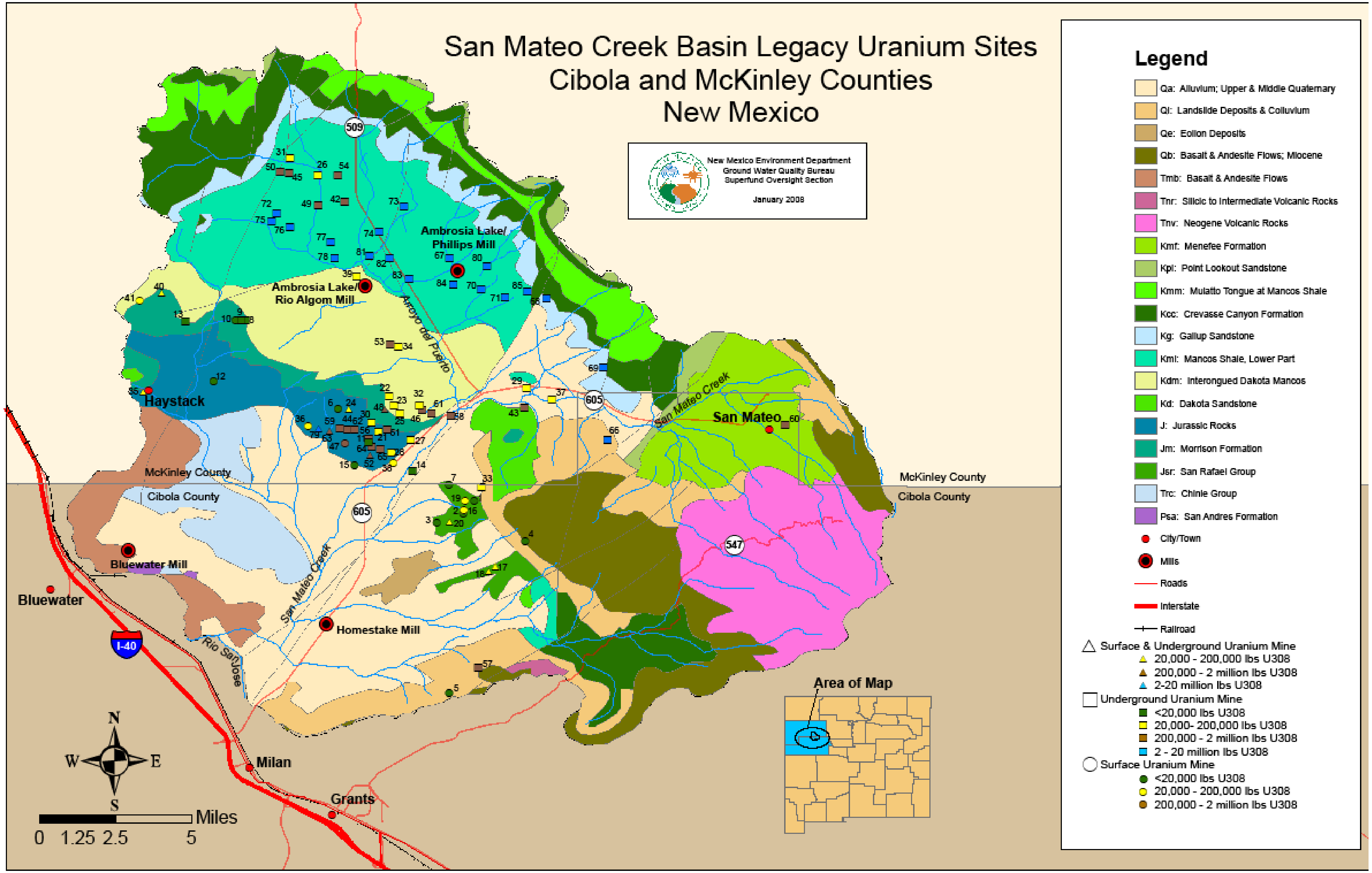
Symbology for mines is derived from Ref. 8 according to the following schema:

- Surface and underground, underground, and surface uranium mine categorization (Ref. 85).
- Production categorization (Ref. 86).

See Table 1 for mine information.

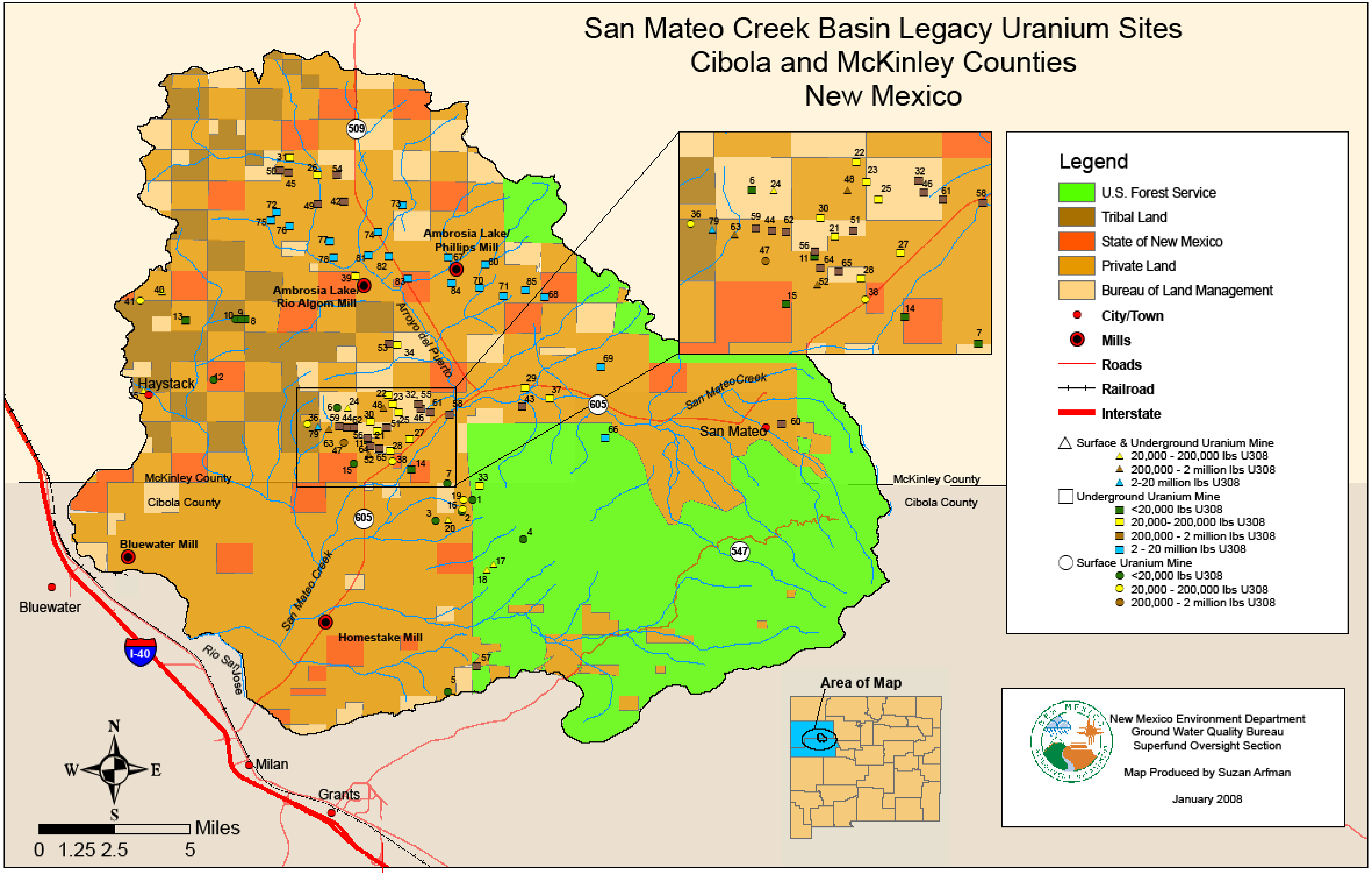
Ref. 4, 5, 6, 8, 87, 88

Figure 2: Bedrock geology of the San Mateo Creek drainage



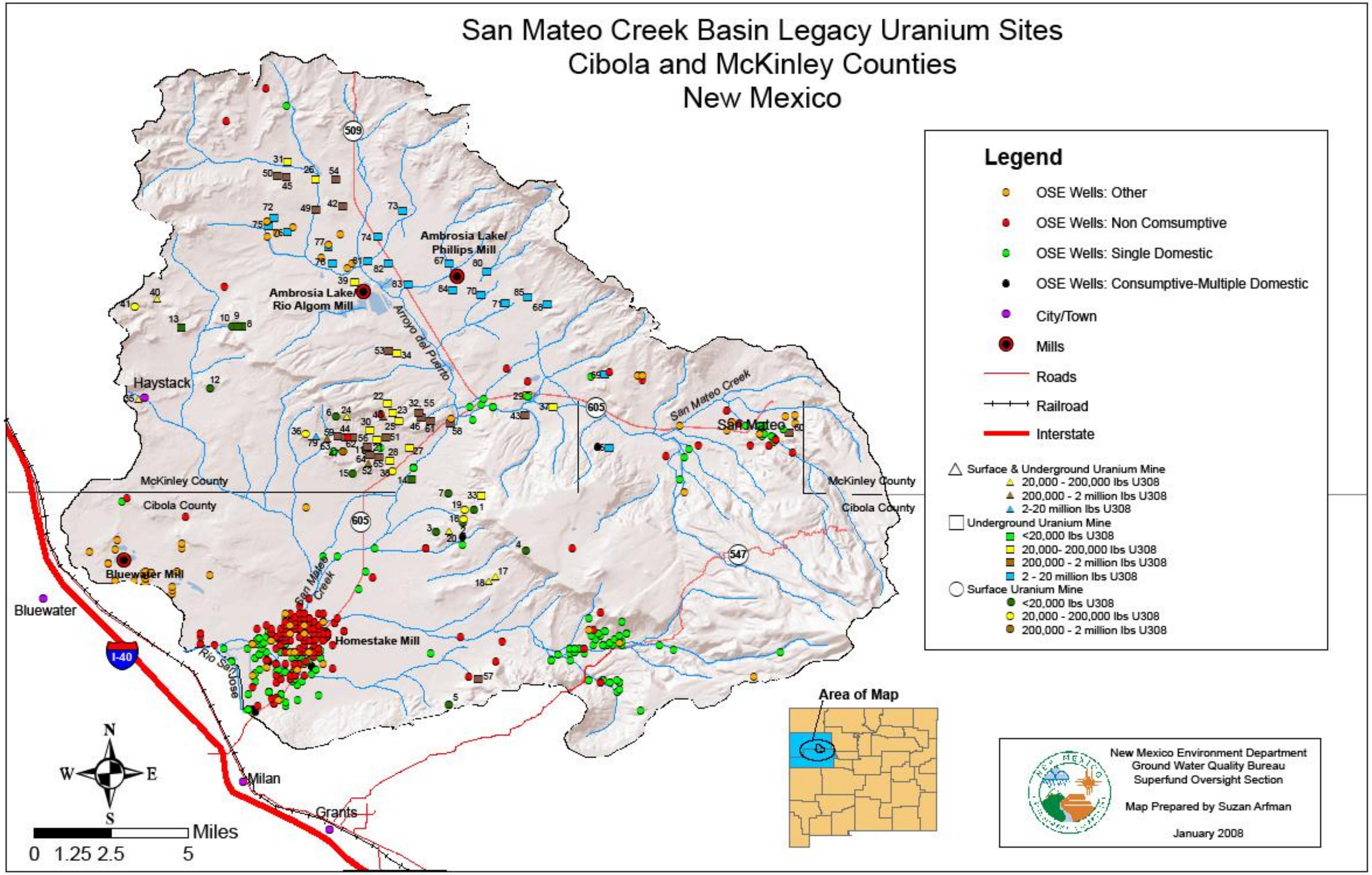
References as for Figure 1 plus Ref. 89

Figure 3: Surficial landownership within the San Mateo Creek drainage basin



References as for Figure 1

Figure 4: Wells within the San Mateo Creek basin that are registered with the New Mexico Office of the State Engineer



References as for Figure 1 plus Ref. 90 (see notes)

Notes to Figure 4:

Wells data from Ref. 90, and are summarized by use categories (Ref. 91, 92) in this figure as follows:

- OSE wells: Other = includes DEW, EXP, MIN, MON, NOT, OBS, PRO, and PUB categories and entries with no category (i.e., blanks)
- OSE wells: Non consumptive = includes IND, IRR, SAN, STK categories
- OSE wells: Single domestic = includes DOM category
- OSE wells: Consumptive—multiple domestic = includes MUL, MOB, MDW categories

Figure 5: Google Earth map of the Grants Mining District and Roca Honda Resources ground water sample locations, northwestern New Mexico.

Figure 6: Composite electric log of geologic strata in the Ambrosia Lake-San Mateo area, northwestern New Mexico

(Ref. 52).

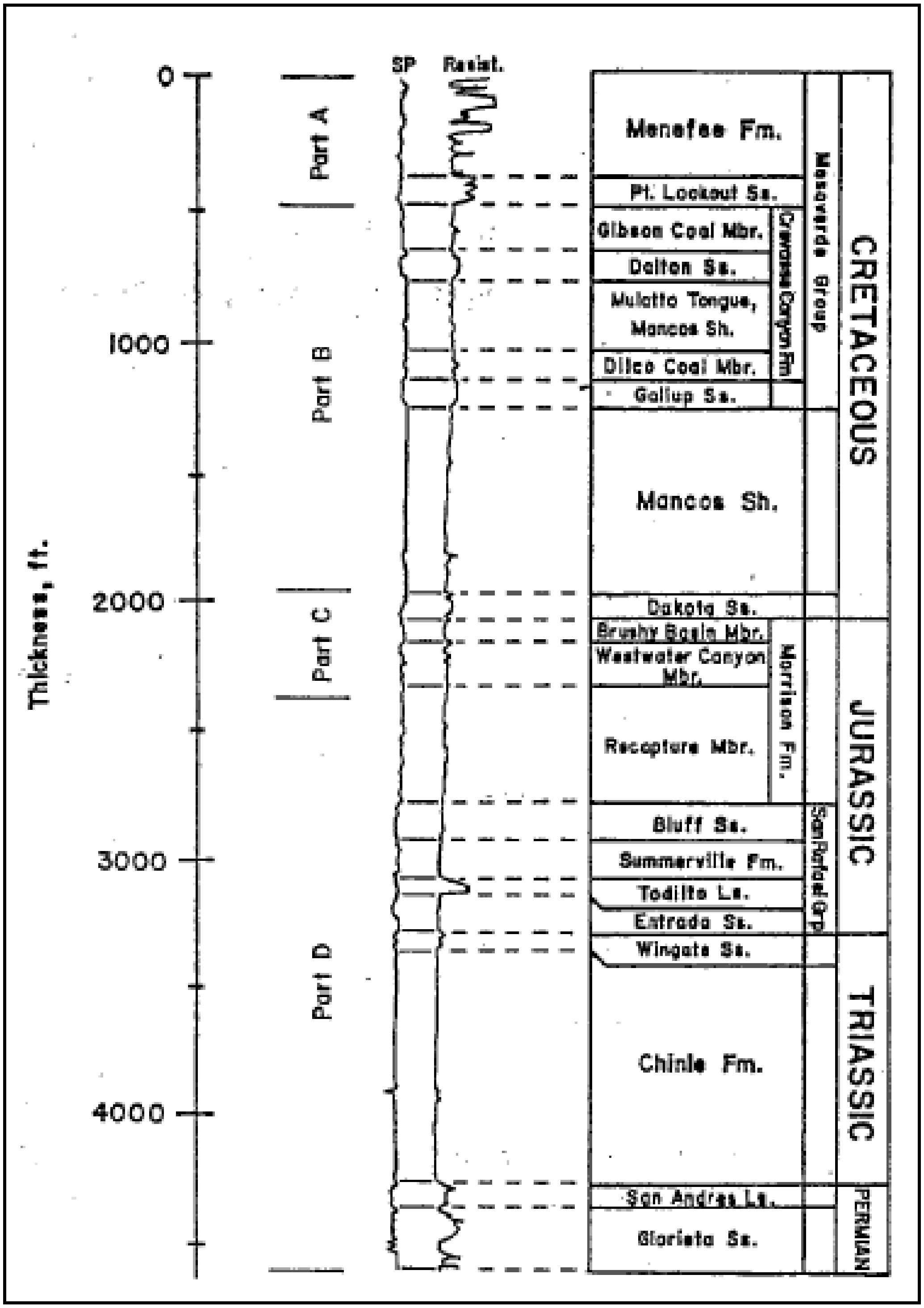


Figure 7: Geologic log from the Johnny M Mine, Ambrosia Lake area, northwestern New Mexico (Ref. 71)

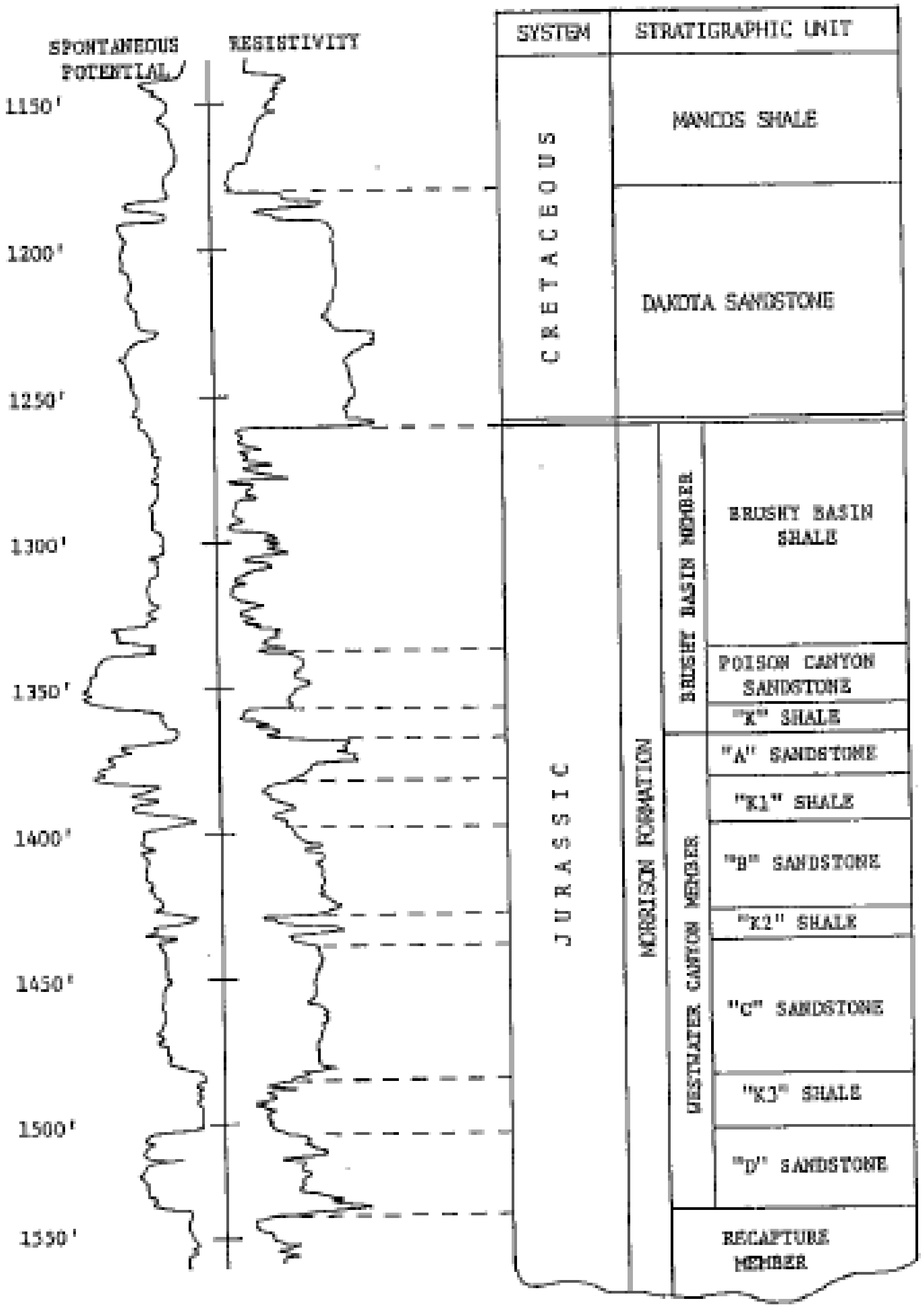


FIGURE 2—LOG FROM THE JOHNNY M MINE.

Figure 8: **X-Y chart of major ion concentrations in mg/L for the Grants Mining District and Roca Honda Resources sample locations, northwestern New Mexico.**

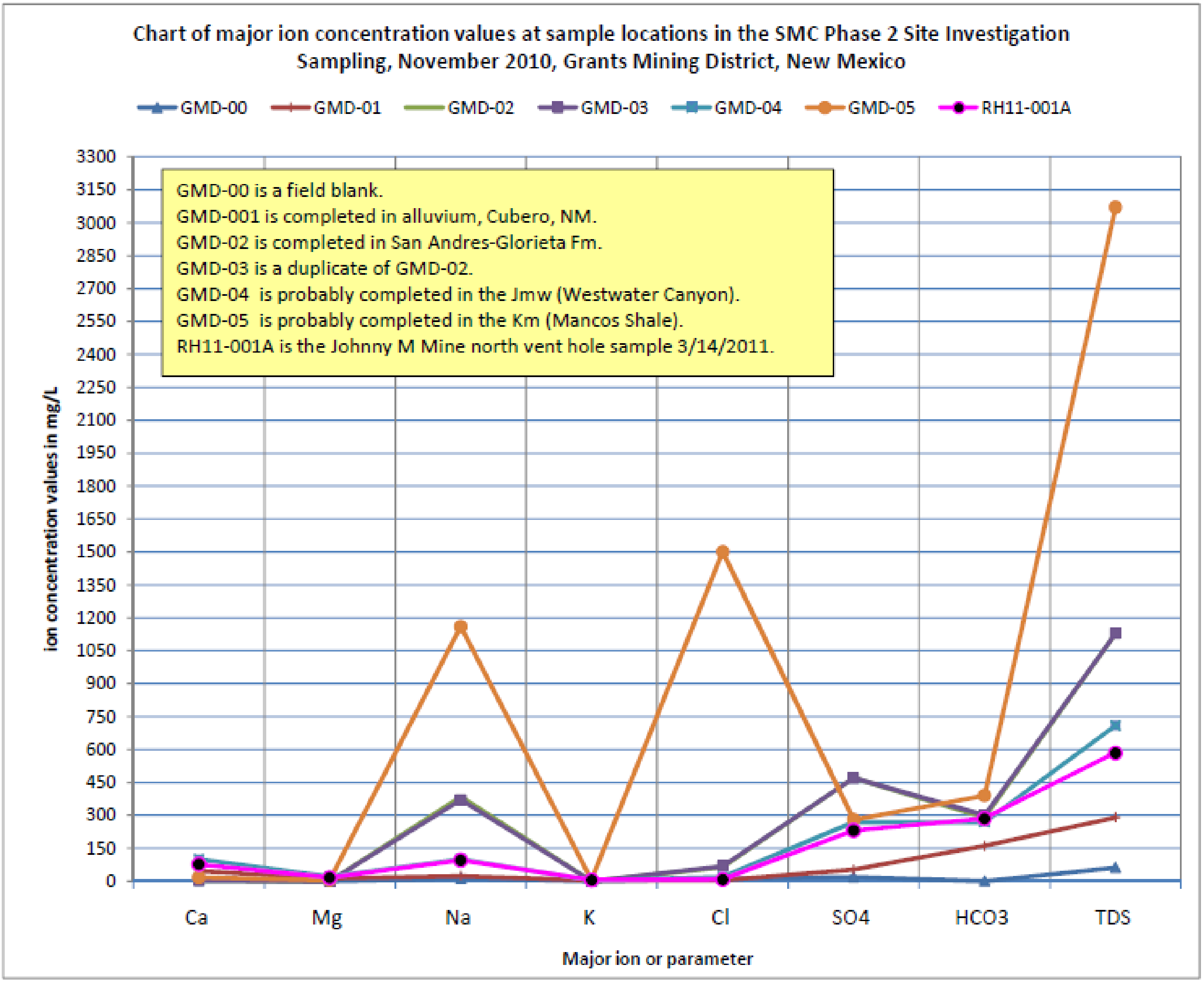


Chart of major ion concentration values at sample locations in the SMC Phase 2 Site Investigation Sampling, November 2010, Grants Mining District, New Mexico

GMD-00 is a field blank.
GMD-001 is completed in alluvium, Cubero, NM.
GMD-02 is completed in San Andres-Glorieta Fm.
GMD-03 is a duplicate of GMD-02.
GMD-04 is probably completed in the Jmw (Westwater Canyon).
GMD-05 is probably completed in the Km (Mancos Shale).
RH11-001A is the Johnny M Mine north vent hole sample 3/14/2011.

Figure 9: **X-Y chart of trace element concentrations in ug/L for the Grants Mining District and Roca Honda Resources sample locations, northwestern New Mexico.**

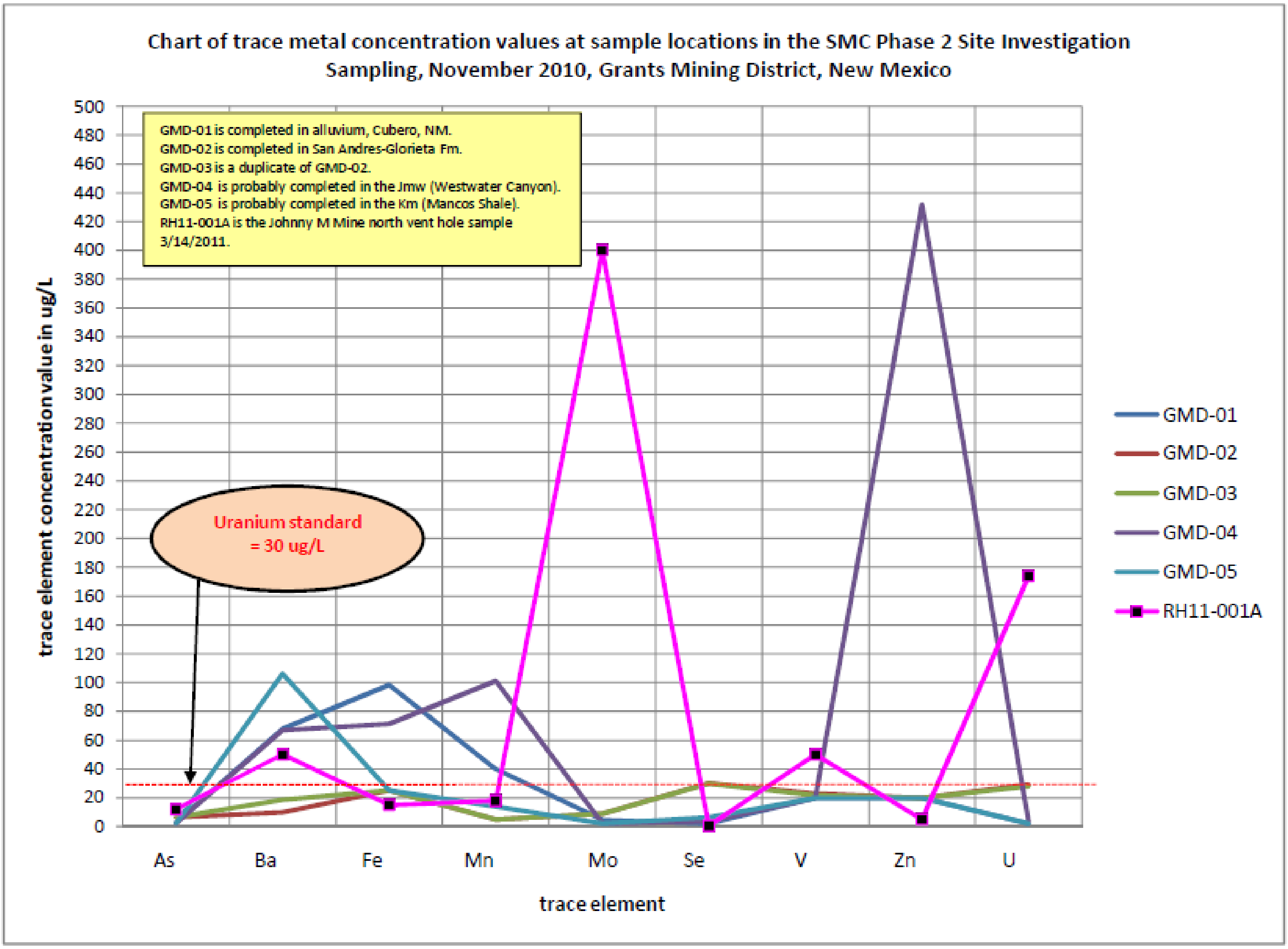


Chart of trace metal concentration values at sample locations in the SMC Phase 2 Site Investigation Sampling, November 2010, Grants Mining District, New Mexico

GMD-01 is completed in alluvium, Cubero, NM.
GMD-02 is completed in San Andres-Glorieta Fm.
GMD-03 is a duplicate of GMD-02.
GMD-04 is probably completed in the Jmw (Westwater Canyon).
GMD-05 is probably completed in the Km (Mancos Shale).
RH11-001A is the Johnny M Mine north vent hole sample 3/14/2011.

Uranium standard = 30 ug/L

Figure 10: Trilinear diagram

relative percentage of major ion concentrations in meq/l for ground water samples from the 2008 Bluewater, 2009 San Mateo Creek, and 2010 Grants Mining District samples depicted against average values described in the investigation by Brod 1979 (Ref. 52)

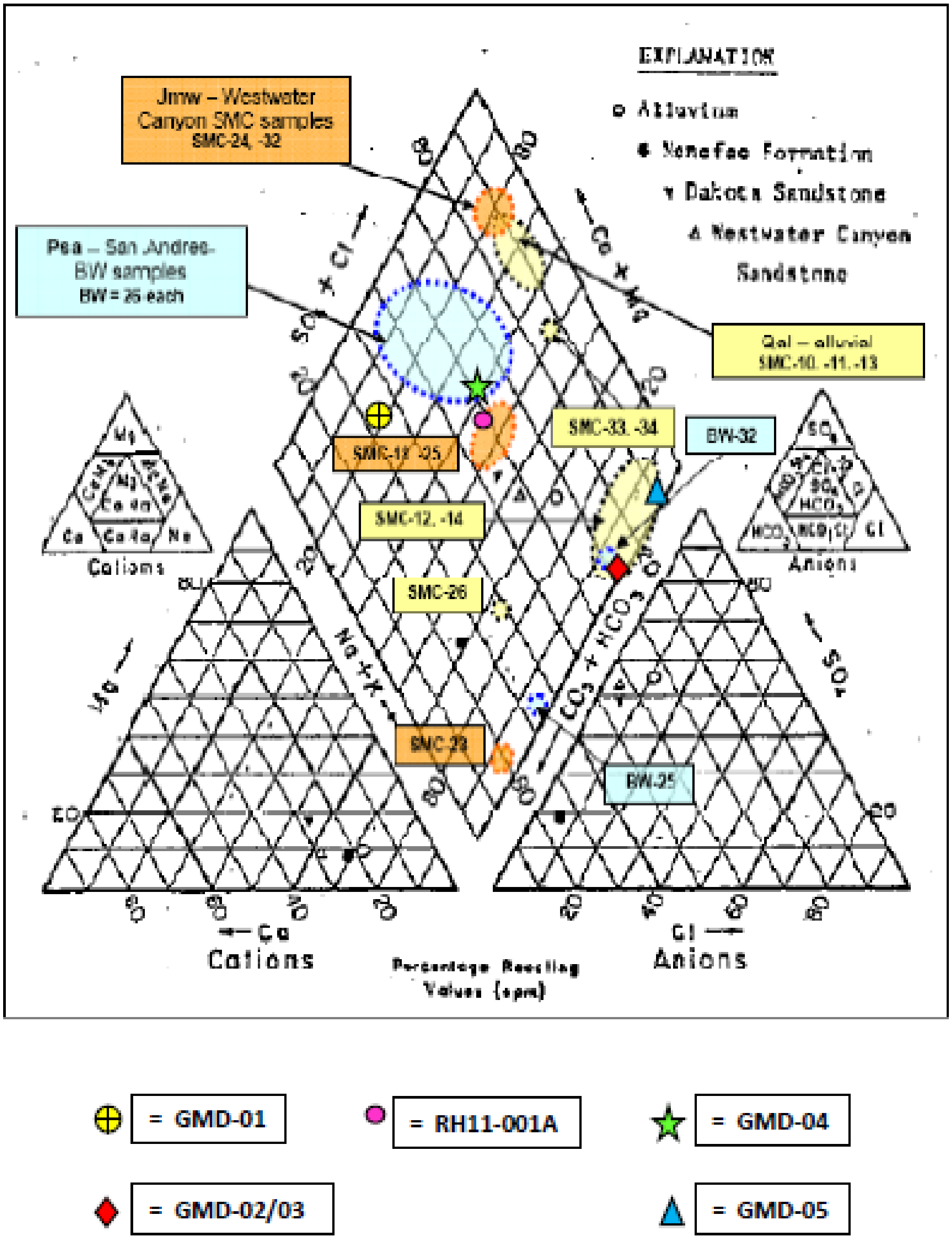


Figure 11: stable isotope values

δ18O and δD for the 2008 Bluewater, 2009 San Mateo Creek, and 2010 Grants Mining District samples, plotted with the Craig meteoric water line, northwestern New Mexico.

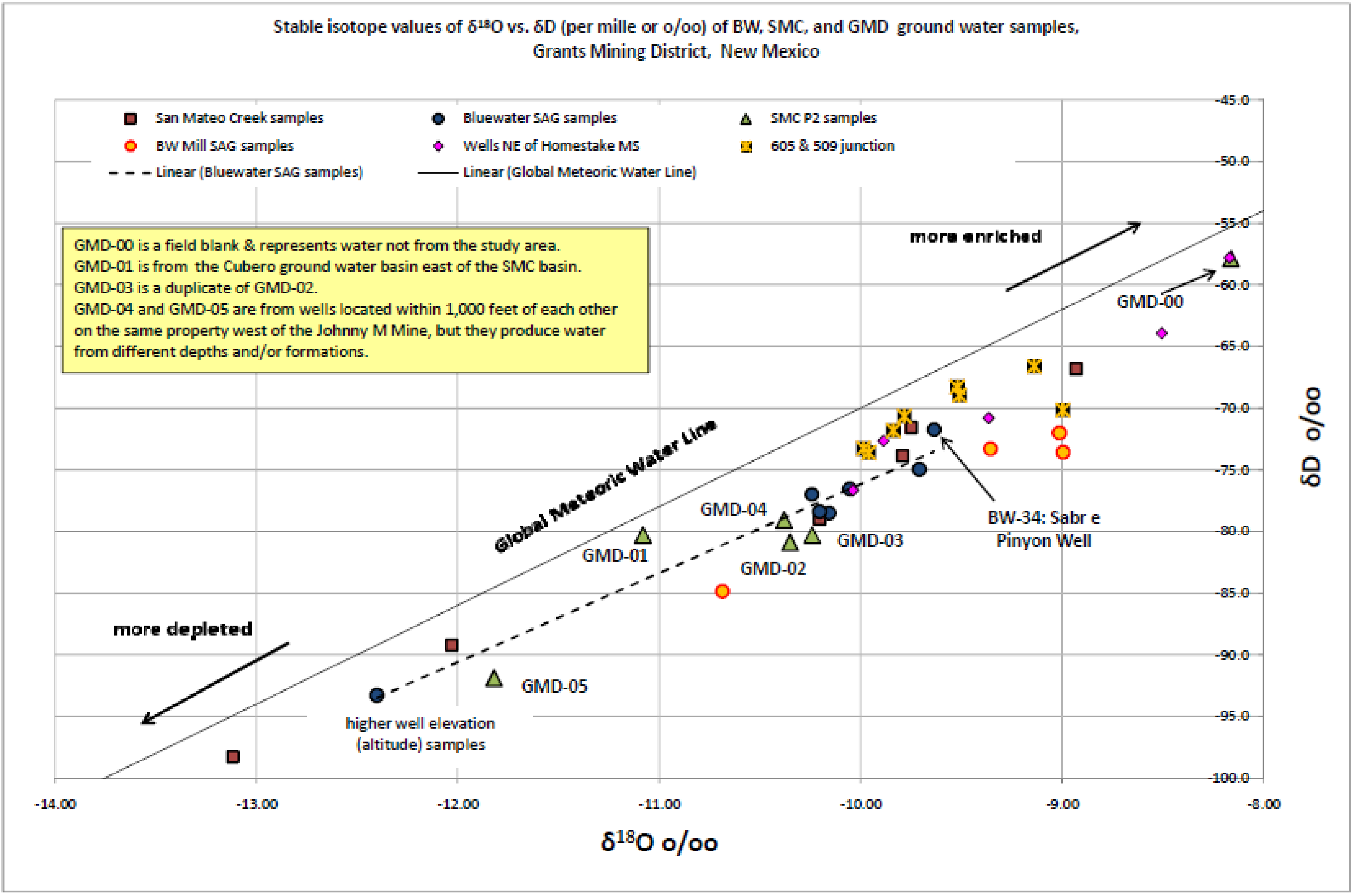


Table 1: Summary of investigations performed under CERCLA within the overall Site boundary

From (Ref. 3)

Site name	CERCLIS ID	Reference no.	Reference page	Actions	Date completed	Reference no.	Reference page
Brown Vandever Mine	NND986669117	36	1	Discovery Preliminary Assessment Archive site Site inspection	03/01/1990 07/17/1990 12/10/1992 12/10/1992	36	2
Anaconda Company Bluewater Uranium Mill	NMD007106891	36	3	Discovery Archive site Preliminary Assessment	04/01/1980 04/01/1980 04/01/1980	36	4
				Preliminary Reassessment	July 1980	43	NA
				Site Investigation	August 2009	44	NA
Haystack Butte Mining District	NMD980878771	36	5	Discovery Preliminary Assessment Archive site Site inspection	09/01/1984 11/01/1984 12/01/1985 12/01/1985	36	6
Kerr-McGee Nuclear Corp	NMD005570015	36	7	Discovery Archive site Preliminary Assessment	02/01/1980 02/01/1981 02/01/1981	36	8
Mt. Taylor Uranium Mine	NMD000778605	36	9	Preliminary Assessment Discovery Site inspection Archive Site	04/01/1981 05/01/1981 04/01/1986 09/26/1994	36	10
Poison Canyon Mining District	NMD981600489	36	11	Discovery Preliminary Assessment Archive site Site inspection	12/01/1986 08/01/1987 10/01/1989 10/01/1989	36	12
UNC San Mateo Mine	NM1223075515	36	13	Discovery Preliminary Assessment Archive Site Site inspection	06/30/1988 01/20/1989 12/07/1995 12/07/1995	36	14
				Engineering Evaluation/Cost Analysis report	08/19/2009	93	
Febco Uranium Mine	NND986669166	36	15	Discovery Preliminary Assessment	07/16/1991 06/11/2001	36	16
Homestake Mining Company mill	NMD007860935	36	17	NPL listing ROD Five year review Five year review	09/08/1983 09/27/1989 09/27/2001 09/26/2006	36	18 18 17 17
Ambrosia Lake Disposal Site (a.k.a. Phillips mill)	NMN000606875	36	19	Discovery	12/19/2007	36	20
				Preliminary Assessment	March 2009	94	NA
Poison Canyon mine	NA			Pre-CERCLIS screen	09/10/2009	95	NA
Red Bluff #1 mine	NA			Pre-CERCLIS screen	09/10/2009	96	NA
Piedra Trieste mine	NA			Pre-CERCLIS screen	09/10/2009	97	NA
Roundy Manol strip mine	NA			Pre-CERCLIS screen	09/10/2009	98	NA
Mesa Top mine	NA			Pre-CERCLIS screen	09/10/2009	99	NA
Malpais mine	NA			Pre-CERCLIS screen	09/10/2009	100	NA
Hope mine	NA			Pre-CERCLIS screen	09/10/2009	101	NA

Site name	CERCLIS ID	Reference no.	Reference page	Actions	Date completed	Reference no.	Reference page
Isabella mine	NA			Pre-CERCLIS screen	09/10/2009	102	NA
Haystack Section 31 mine	NA			Pre-CERCLIS screen	09/10/2009	103	NA
Flat Top mine	NA			Pre-CERCLIS screen	09/10/2009	104	NA
Beacon Hill Gossett mine	NA			Pre-CERCLIS screen	09/10/2009	105	NA
Spencer mine	NA			Pre-CERCLIS screen	09/01/2009	106	NA
T-20 mine	NA			Pre-CERCLIS screen	09/01/2009	107	NA
Flea mine	NA			Pre-CERCLIS screen	09/10/2009	108	NA
Doris mine	NA			Pre-CERCLIS screen	09/10/2009	109	NA
Faith mine	NA			Pre-CERCLIS screen	09/10/2009	110	NA
Dog mine	NA			Pre-CERCLIS screen	09/10/2009	111	NA
Blue Peak mine	NA			Pre-CERCLIS screen	09/10/2009	112	NA
Davenport mine	NA			Pre-CERCLIS screen	09/10/2009	113	NA
Barbara J #3 mine	NA			Pre-CERCLIS screen	09/10/2009	114	NA
Barbara J #2 mine	NA			Pre-CERCLIS screen	09/10/2009	115	NA
Barbara J #1 mine	NA			Pre-CERCLIS screen	09/10/2009	116	NA
Section 25 SEQ mine	NA			Pre-CERCLIS screen	09/01/2009	117	NA
Section 25 open pits mine	NA			Pre-CERCLIS screen	09/10/2009	118	NA
Roundy shaft mine	NA			Pre-CERCLIS screen	09/10/2009	119	NA
Schmitt decline mine	NA			Pre-CERCLIS screen	09/10/2009	120	NA
Beacon Hill mine	NA			Pre-CERCLIS screen	09/10/2009	121	NA

(Ref. 3)

Table 2: Analytical data from the Poison Canyon Mining District (July 1989 sampling)

Ref. 50

Location	**^{238}U**	**^{234}U**	**^{232}Th**	**^{230}Th**	**^{226}Ra**	**^{210}Pb**	**Vanadium**	**Lead**	**Copper**
	pCi/g						**µg/g**		
Background									
A	5.53	6.80	0.50	6.86	6.30	6.60	6	<5	5
B	4.24	4.43	0.81	4.88	4.50	2.20	6	7	8
BJ #3A	1.29	1.22	0.40	3.23	3.92	2.00	12	6	9
Stream/pond sediments									
BJ Stream A	4.64	4.92	1.07	5.95	9.30	5.50	15	9	9
Stock pond	61.50	65.50	1.75	34.50	38.20	33.60	88	63	11
Waste rock/soils									
BJ #1	890.00	910		1150	1060	860	830	74	9
BJ #3B	140	142		175	72	93	66	5	<5
BJ #3C	5840	5730		5990	5600	4320	260	310	<5

Notes:

^{238}U = uranium 238
^{234}U = uranium 234
^{232}Th = thorium 232
^{230}Th = thorium 230
^{226}Ra = radium 226
^{210}Pb = lead 210
pCi/g = picocuries per gram
µg/g = micrograms per gram

(From Ref. 3)

Table 3: **Ground water usage from wells within the Site boundary**

Ref. 90

GROUND WATER USAGE		**TOTALS**	
Consumptive			213
	Single domestic wells	203	
	Multiple domestic and community wells	10	
Irrigation, sanitary, industrial, and stock wells			241
Other well usages	Including dewatering, exploration, mining, milling, oil, monitoring, no recorded use of right, observation, prospecting, construction, and no documented usage category		79

(From Ref. 3)

Table 4: Available well completion data for SI sampling event

(Ref. 3)

Sample ID	Alternative well IDs	Latitude (NAD83)	Longitude (NAD83)	Water Level (ft-BGS)	Well Depth (ft)	Screened interval	Lithology/stratigraphic unit opposite screened interval	Notes	Inferred completion aquifer
SMC-00	**Field Blank** collected at SMC-01 well location								
SMC-01	BWSI-34	35.24748	-107.92398	150	275	241-275	limestone/dolomite/chalk		
	HMC-951								
	B28-S-247			152					
SMC-03	B00686*	35.20425	-107.89780	81	138	120-134	sandstone/gravel/ conglomerate		Bedrock?
SMC-04		35.20645	-107.87140		340				Bedrock?
SMC-05	B-01072*	35.20420	-107.87292	180	280 510	484-510	sandstone/gravel/ conglomerate		Bedrock?
SMC-06	**Field Blank** collected at SMC-07 well location								
SMC-07		35.44246	-107.82333		1200				Bedrock
	14.9.18.243**			744	800		Westwater Canyon		
SMC-08		35.26671	-107.83545	~28	~200				Alluvial
SMC-09		35.23852	-107.78490						Alluvial
SMC-10	HMC-914	35.27774	-107.83082	42	93		alluvium		Alluvial
	12.9.7.343**			58 (11/30/1955)	98		sand and gravel (alluvium)		
SMC-11	HMC-920			33			alluvium		Alluvial
	12.10.12.433**			58.1 (11/30/1955) 58.1 (7/25/56)	100		alluvium		
SMC-12	HMC-950			26	81		alluvium		Alluvial
	12.10.12.221**			67.7 (07/26/1956)	81		alluvium		
SMC-13	HMC-921			39	73		alluvium		Alluvial
	B00415 O-13*			50	74				
SMC-14	121.10.14.212**	35.27519	-107.85929	50.1 (07/1956)			alluvium		Alluvial
	HMC-922			51 59	96 101		alluvium		
SMC-15	**Equipment blank** post SMC-13								
SMC-16		35.34801	-107.73715					pump set at ~200'	Bedrock?
SMC-17		35.35756	-107.80773	65.5	>400				Alluvial
SMC-18		35.34829	-107.80320	82.3	102				Bedrock?
SMC-20	B-01115	35.34903	-107.77978	204	478	458-478	sandstone/gravel/conglom-erate		Bedrock
	Strathmore-111				478				

Sample ID	Alternative well IDs	Latitude (NAD83)	Longitude (NAD83)	Water Level (ft-BGS)	Well Depth (ft)	Screened interval	Lithology/stratigraphic unit opposite screened interval	Notes	Inferred completion aquifer
SMC-21		35.36355	-107.76920						Alluvial?
SMC-22	B-01485*	35.32519	-107.82638	280	580 ~500	500-560	red coarse sandstone, red sandstone	Former supply to mine camp	Bedrock?
SMC-23	Strathmore-116	35.34515	-107.78606	80	260	220-260	Jmw		Bedrock
	B-1636						white sand		
	B-0659*			190	220		sandstone/Dakota		
SMC-24	Strathmore-138	35.34459	-107.78514	86	170		Jmw		Bedrock
	B-0659*			190	220		sandstone/Dakota		
SMC-25	B-1636*	35.34713	-107.78334	80	260	220-260	white sand		Bedrock?
	13.9.22.111**			220			Westwater Canyon		
SMC-26	Strathmore-115	35.34658	-107.77467	88	88		Qal		Alluvial
					130				
	B-00415-O5*			72	95				
	B-00415-O6*			73	90		Shallow alluvium/basin fill		
	B-00415-O7*			74	80				
SMC-28		35.34879	-107.76743	520	590				Bedrock
SMC-30	B-00815*	35.33671	-107.65423	260	300	270-290	white sandstone		Bedrock?
SMC-31	B-00524*	35.33506	-107.63823	260	520	400-480	gray coarse sand		
	13.8.24.341**				250		Kmf		
	13.8.24.341**			139 (3/1978)	500		Kmf		
SMC-32	13.9.16.411**	35.35452	-107.79461		250		Westwater Canyon	Pump set at ~200'	Bedrock?
	13.9.16.413**				250		Westwater Canyon		
SMC-33	B-00415-O8*	35.32146	-107.81759	30	54		shallow alluvium/basin fill		Alluvial
	B-00415-O9*				57				
	B-00415-O10*			32	59				
	B-00415-O11*				72				
	13.9.29.341**				455		T c		
SMC-34	13.9.28.111**	35.332654	-107.80274	58.2 (08/05/1977)	125		alluvium		Alluvial
SMC-35	**Field duplicate** associated with SMC-11							[redacted]	[redacted]
SMC-36	**Field duplicate** associated with SMC-26							[redacted]	[redacted]
SMC-39		35.34677	-107.7758	86.6	88			Low yield; Isotope sample only.	Inferred from depth and other references cited
	13.9.22.212**			87.5 (12/1957)	95		alluvium		

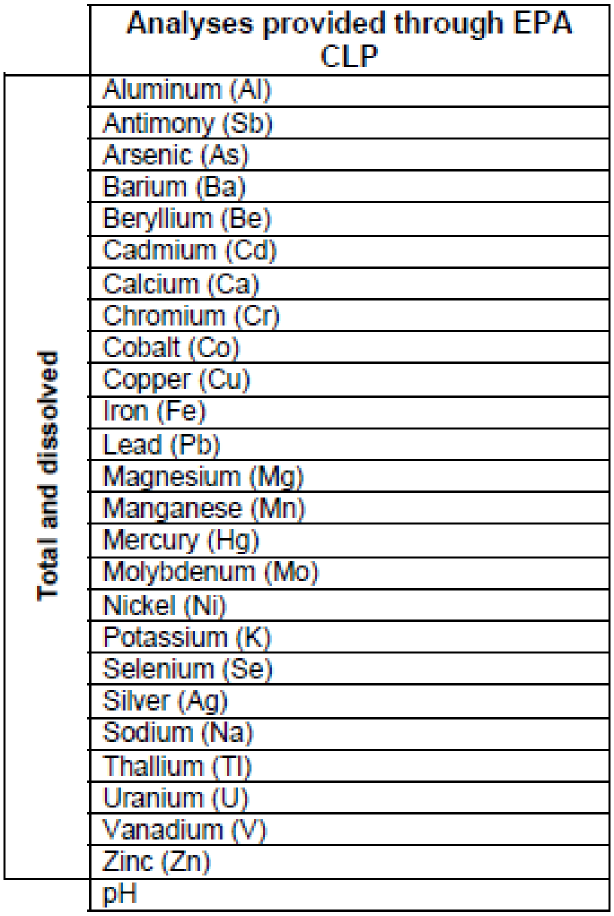
* New Mexico Office of the State Engineer well record identified by EPA-provided overplot of iWATERS database (Ref. 90) with well locations determined global positioning instrument during sampling (Ref. 122).

** Inferred well identification by wells from Ref. 123 within 200 meters of sampled well.

Table 5: **Grants Mining District sample well location, construction, and Hydrogeologic information, San Mateo Creek Phase 2 site investigation, northwestern New Mexico.**

Sample ID	Latitude (deg. decimal NAD83)	Longitude (deg. decimal NAD83)	OSE Well Permit No.	Well surface altitude (ft)	Well depth (ft)	Well screened interval (ft)	Well hydrogeologic & construction information and/or other comments
GMD-00							Field blank collected at GMD-01 location
GMD-01	35.08629279	-107.52736084	RG-87964	7101	126	116-126	Depth to static water level = 22 ft. Well completed in alluvial fill 22-126 ft.
GMD-02	35.276400	-107.843510	B-01771	6975	635	520-600	Completed in San Andres aquifer. Pea gravel pack from 520-200 ft = potential hydraulic communication w/ Chinle and/or alluvium?
GMD-03							Duplicate sample of GMD-02.
GMD-04	35.36062502	-107.72822091	B-01778	6866	940	840-860	Depth to static water level = 625 ft. Not sure of hydrostratigraphic unit: Dakota Sandstone or Morrison Fm-Westwater Canyon at this location?
GMD-05	35.08627620	-107.72814196	B-01544	6714	715	600-700	Depth to static water level = 624 ft. Not sure of hydrostratigraphic unit but based on well depth & water chemistry it looks like Mancos Shale at this location?

Table 6: **Grants Mining District water sample analyses provided through EPA Contract Laboratory Program (CLP)**



	Analyses provided through EPA CLP
Total and dissolved	Aluminum (Al)
	Antimony (Sb)
	Arsenic (As)
	Barium (Ba)
	Beryllium (Be)
	Cadmium (Cd)
	Calcium (Ca)
	Chromium (Cr)
	Cobalt (Co)
	Copper (Cu)
	Iron (Fe)
	Lead (Pb)
	Magnesium (Mg)
	Manganese (Mn)
	Mercury (Hg)
	Molybdenum (Mo)
	Nickel (Ni)
	Potassium (K)
	Selenium (Se)
	Silver (Ag)
	Sodium (Na)
	Thallium (Tl)
	Uranium (U)
	Vanadium (V)
	Zinc (Zn)
	pH

Table 7: **Grants Mining District water sample analyses provide through Hall Analytical Environmental Laboratory (HAEL).**

Analytes provided by Hall Laboratories
bicarbonate
carbonate
chloride
gross alpha
gross beta
nitrate (as N) + nitrite (as N)
radium-225
radium-228
sulfate
total alkalinity (as CaCo3)
total dissolved solids
uranium-234
uranium-235
uranium-238
apparent C14 age (fraction modern)
C13/C12 ratio
δD of water
δO18 of water

Table 8: Summary of data values

describing: the sample number, field parameters; individual chemical values; and isotopic results for the 2010 Grants Mining District set of samples San Mateo Creek Phase 2 site investigation northwestern New Mexico (includes Roca Honda Resources samples).

Sample Number	Latitude (NAD83)	Longitude (NAD83)	Sample Date	Tempera-ture (T) °C	Dissolved Oxygen (DO) mg/L	Specific Conduc-tance (SC) µS/cm	Oxidation Reduction Potential (ORP)	Field pH	Lab pH	Total Dissolved Solids (TDS) mg/L	Total anions meq/L	Total cations meq/L	Charge balance error
EPA MCL													
NM WQCC								6 - 9		1000			<10%
GMD-00	FIELD	BLANK	11/8/2010	FIELD	BLANK				7	62	1.07	0.84	12.03
GMD-01	35.086293	-107.527361	11/8/2010	14.05	0.45	420	-234.4	7.06	7	291	3.86	4.50	7.61
GMD-02	35.360385	-107.728142	11/9/2010	16.25	0.44	1503	-290.9	8.39	8.7	1130	16.36	16.96	1.81
GMD-03	DUPE	GMD-02	11/9/2010	DUPE	GMD-02				8.7	1130	16.64	16.31	1.00
GMD-04	35.360625	-107.728221	11/8/2010	22.33	1.27	1093	-31.2?	7.15	7.4	709	10.60	11.12	2.39
GMD-05	35.086276	-107.728142	11/8/2010	19.77	0.49	4937	-179.9	7.69	7.8	3070	54.60	51.93	2.51

Sample Number	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	Ag (µg/L)	Al (µg/L)	As (µg/L)	Ba (µg/L)	Be (µg/L)	Cd (µg/L)	Co (µg/L)	Cr (µg/L)	Cu (µg/L)	F (mg/L)	Fe (µg/L)	Hg (µg/L)	Mn (µg/L)	Mo (µg/L)	Ni (µg/L)	NO_3+NO_2 (mg/L)	Pb (µg/L)	Sb (µg/L)	Se (µg/L)	Tl (µg/L)	V (µg/L)	Zn (µg/L)
EPA MCL										10	2000	4	5		100	1300	4		2				10	15	6	50	2		
NM WQCC					250	600		50	5000(i)	100	1000		10	50(i)	50	1000	1.6	1000	2	200	1000(i)	200(i)	10	50		50			10000
GMD-00	3.01	0.997	13.4	<1.0	11	20	<20	<10	<100	<2.0	<10	<5	<5	<20	<10	37.5	no data	<25	<0.2	<5	<4.0	<20	<1.0	<2	<2	<2.0	<2	<20	48.4
GMD-01	45.6	13.3	23.4	4.3	5	52	160	<10	<100	2.6	67.9	<5	<5	<20	<10	<20	no data	98.2	<0.2	39.7	4.7	<20	<1.0	<2	<2	<2.0	<2	<20	<20
GMD-02	3.27	0.345	385	<1	64	470	290	<10	<100	6.6	<10	<5	<5	<20	<10	<20	no data	<25	<0.2	<5	9.1	<20	<1.0	<2	<2	30.1	<2	22.9	<20
GMD-03	3.17	0.338	370	<1	68	470	300	<10	<100	6.3	18.7	<5	<5	<20	<10	<20	no data	<25	<0.2	<5	8.8	<20	<1.0	<2	<2	29.9	<2	21.6	<20
GMD-04	100	20.5	99.8	3.9	19	270	270	<10	<100	<2	67	<5	<5	<20	<10	<20	no data	71.3	<0.2	101	<4	<20	<1.0	<2	<2	3.8	<2	<20	432
GMD-05	17.6	4.89	1160	7.2	1500	280	390	<10	<100	<2	106	<5	<5	<20	<10	<20	no data	<25	<0.2	13.8	<4	<20	<4.0	<2	<2	6.6	<2	<20	<20

Sample Number	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	^{226}Ra (pCi/L)	^{228}Ra (pCi/L)	U (µg/L)	^{238}U (pCi/L)	^{235}U (pCi/L)	^{234}U (pCi/L)	∂ ^{2}H per mil (‰)	∂ ^{18}O per mil (‰)	∂ ^{13}C per mil (‰)	Apparent C14 age in years
EPA MCL	15	50	5	5	30							
NM WQCC			30	30	30							
GMD-00	-0.132	0.07	-0.21	-0.89	<2.0	-0.017	0.047	-0.093	-57.9	-8.16	-19.7	5150
GMD-01	1.28	3.00	-0.07	0.82	<2.0	0.864	0.147	1.598	-80.3	-11.08	-11.4	890
GMD-02	34.1	-0.30	0.17	0.28	29.2	10.096	0.349	23.263	-80.9	-10.35	-9.7	8150
GMD-03	22.8	1.90	0.16	0.84	27.9	9.107	0.533	20.137	-80.3	-10.24	-8.50	7890
GMD-04	17.3	7.23	3.33	2.67	3.0	0.877	0.036	1.255	-79.1	-10.38	-10.10	3690
GMD-05	1.33	6.11	1.05	1.39	<2.0	0.012	-0.013	0.106	-91.9	-11.82	-11.50	28170

Table 9: Water sample parameter exceedances applicable federal and state drinking water and other state standards, San Mateo Creek Phase 2 site investigation, northwestern New Mexico.

Drinking water parameter	Standard concentration	Sample GMD-01	Sample GMD-02	Sample GMD-03	Sample GMD-04	Sample GMD-05	Sample RH11-001A
gross alpha	15 pCi/l (MCL)	1.28 +/- 0.76 pCi/l	34.1 +/- 7.43 pCi/l	22.8 +/- 5.34 pCi/l	17.3 +/- 4.01 pCi/l	1.33 +/- 1.46 pCi/l	263 +/- 8.7 pCi/l
radium 226 + radium 228	5 pCi/l (MCL)	0.75 +/- 0.76 pCi/l	0.45 +/- 0.70 pCi/l	0.99 +/- 0.95 pCi/l	6.0 +/- 1.41 pCi/l	2.44 +/- 1.28 pCi/l	80.5 +/- 2.27 pCi/l
uranium	0.030 mg/l (MCL)	< 0.002 mg/l	0.029 mg/l	0.029 mg/l	0.003 mg/l	<0.002 mg/l	0.174 mg/l
pH (field)	6.5 – 8.5 s.u. (SMCL)	7.06	8.39	8.39	7.15	7.69	n/a
sulfate	250 mg/l (SMCL)	52 mg/l	470 mg/l	470 mg/l	270 mg/l	280 mg/l	231 mg/l
TDS	500 mg/l (SMCL)	291 mg/l	1130 mg/l	1130 mg/l	709 mg/l	3070 mg/l	584 mg/l
chloride	250 mg/l (SMCL & NMWQCC)	11 mg/l	5 mg/l	64 mg/l	68 mg/l	19 mg/l	1,500 mg/l
manganese	0.050 mg/l (SMCL)	0.040	<.005 mg/l	<0.005 mg/l	0.066 mg/l	0.014 mg/l	0.018 mg/l
TDS	1,000 mg/l (NMWQCC)	291 mg/l	1130 mg/l	1130 mg/l	709 mg/l	3070 mg/l	584 mg/l

MCL: maximum contaminant level (Ref. 12).
SMCL: secondary maximum contaminant level (Ref. 11).
NMWQCC: New Mexico Water Quality Control Commission (Ref. 15).

s.u.: standard units
pCi/l: pico Curies per liter
mg/l: milligrams per liter
TDS: total dissolved solids

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