Preassessment Screen and Determination: Rio Algom Mines and Quivira Mill Site, McKinley County, New Mexico

New Mexico Office of Natural Resources Trustee
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Acronyms and Abbreviations

ACL	alternate concentration limit
ALC	aquatic life criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
cm	centimeter
cpm	counts per minute
CWA	Clean Water Act
DAF	dilution/attenuation factor
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
Eco-SSL	ecological screening level
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
ft	feet
gpm	gallons per minute
µg/L	micrograms per liter
µR/hr	micro-Roentgens per hour
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NaCl	sodium chloride
$NaClO_3$	sodium chlorate
$Na_2U_2O_7$	sodium diuranate
$(NH_4)_2U_2O_7$	ammonium diuranate
NMED	New Mexico Environment Department
NRC	Nuclear Regulatory Commission
NRDA	natural resource damage assessment
ONRT	Office of Natural Resources Trustee
pCi/µg	picocuries per microgram
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PMP	probable maximum precipitation
PRP	potentially responsible party
QMC	Quivira Mining Company
RCRA	Resource Conservation and Recovery Act

SDWA	Safe Drinking Water Act
SMCL	secondary maximum contaminant level
SO_4	sulfate
SSL	soil screening level
s.u.	standard units
TDS	total dissolved solids
TI	tailings impoundment
UNC	United Nuclear Corporation
U.S. EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

1. Introduction

Hazardous substances[1] have been released to the environment as a result of mining and milling activities at uranium mines and the Quivira Mill owned by Rio Algom Mining Ltd. (the Site) in McKinley County, New Mexico. Specifically, the Site includes nine section mines and associated facilities owned by Rio Algom that are located north of the mill area and the Quivira Mill. The State of New Mexico (the State) Office of Natural Resources Trustee (ONRT) has begun the process of assessing natural resource damages at the site in accordance with the natural resource damage assessment (NRDA) regulations promulgated by the U.S. Department of the Interior (DOI) at 43 CFR Part 11 (hereafter, the DOI regulations). These regulations are not mandatory. However, assessments performed in compliance with these regulations have the force and effect of a rebuttable presumption in any administrative or judicial proceeding under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 U.S.C. § 9607(f)(2)(C)]. The first step in the process established by the DOI regulations is the preparation of a preassessment screen.

1.1 Intent of the Preassessment Screen

The purpose of a preassessment screen is to determine whether a discharge or release of a hazardous substance warrants conducting a NRDA. It is intended to be based on "a rapid review of readily available information . . . [to] ensure that there is a reasonable probability of making a successful claim" [43 CFR § 11.23(b)]. A preassessment screen is not intended to serve as a completed assessment of natural resources injuries or damages.

To prepare this preassessment screen, ONRT relied largely on existing data and engineering reports developed for the Site (e.g., AVM Environmental Services and Applied Hydrology Associates, 2000; Maxim Technologies, 2001; INTERA, 2007). All literature and data sources relied on in the preparation of this preassessment screen are presented in the references provided at the end of this report.

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1. The term "hazardous substance" refers to a hazardous substance as defined in Section 101(14) of CERCLA [43 CFR § 11.14(u)]. This includes hazardous substances designated or listed by Sections 311(b)(2)(A) and 307(a) of the Federal Water Pollution Control Act (a.k.a. the Clean Water Act, or CWA), by Section 102 of CERCLA, by Section 3001 of the Solid Waste Disposal Act (a.k.a. the Resource Conservation and Recovery Act, or RCRA), or listed by Section 112 of the Clean Air Act.

1.2 Criteria to Be Addressed by the Preassessment Screen

The content and requirements of a preassessment screen are described at 43 CFR § 11.23. As described in the regulations, the State evaluated whether the following criteria have been met [43 CFR § 11.23(e)]:

1. **A release of a hazardous substance has occurred.** This criterion was evaluated by reviewing information on sources of hazardous substances, evidence of releases of hazardous substances to the environment, and data demonstrating elevated concentrations of hazardous substances in natural resources.

2. **Natural resources for which the State may assert trusteeship have been or are likely to have been adversely affected by the release.** This criterion was evaluated by reviewing data on the magnitude of natural resources exposure to hazardous substances relative to potential adverse effect thresholds.

3. **The quantity and concentration of the released hazardous substance are sufficient to potentially cause injury to those natural resources.** This criterion was evaluated by comparing concentrations of hazardous substances in surface water and groundwater to regulatory criteria, and by comparing concentrations of hazardous substances in geologic resources to potential injury thresholds.

4. **Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost.** Reasonable cost is defined in the DOI regulations as meaning that "the Injury Determination, Quantification, and Damage Determination phases have a well-defined relationship to one another and are coordinated . . . and the anticipated cost of the assessment is expected to be less that the anticipated damage amount" [43 CFR § 11.14 (ee)]. Although the specific elements of injury determination, quantification, and damage determination have not yet been developed for this Site, ONRT does not anticipate difficulties in developing a well-defined and coordinated process. Further, monitoring data for groundwater and other natural resources already exist for the Site, and more data are being collected as part of remedial planning and response activities. ONRT believes that additional data collection for groundwater and other trust resources could be conducted at reasonable cost, as defined in the regulations.

5. **Response actions carried out or planned will not sufficiently remedy the injury to natural resources without further action.** Response actions over the past 25+ years include covering and capping of tailings impoundments (TIs; AVM Environmental Services and Applied Hydrology Associates, 2000), reclamation and revegetation of some evaporation ponds (Brummett et al., 2006), construction of interceptor trenches to intercept contaminated groundwater, and pumping of contaminated groundwater (Rio

> Algom Mining, 2007). Despite these efforts, concentrations of hazardous substances continue to exceed injury thresholds in some natural resources, sometimes by orders of magnitude. Additional reclamation and remediation actions have been proposed. Absent the complete removal of contaminated mine and mill waste and the extraction and treatment of contaminated groundwater, it is likely that areas of the Site will remain sources of hazardous substances to State resources for many years. Moreover, none of these remedies will address past and ongoing injuries to natural resources.

As described in greater detail below, the State has concluded that the determination criteria outlined in the DOI regulations have been satisfied, and therefore the State intends to proceed with further NRDA activities at the Site.

2. Information on the Site [43 CFR § 11.24]

2.1 Location and Description

The Site is located in northwestern New Mexico (Figure 2.1), approximately 20 miles north of Grants. The Site, which is which is located in the Ambrosia Lake subdistrict of the Grants Mineral Belt, includes underground workings and associated facilities at the nine Rio Algom section mines[1] and a mill facility (Kelly et al., 1980; Maxim Technologies, 2001). The Site currently includes two TIs (Impoundments 1 and 2, now combined into one large impoundment), one lined evaporation pond (Pond 9), and office support buildings. When operational, the Site also included a total of eight evaporation ponds near the TIs (Ponds 3 through 10), six of which were unlined, as well as the former mill site, and a series of lined evaporation ponds located southeast of the tailings area (former Section 4 Ponds, Ponds 11 through 21). All mill facility units except the former Section 4 Ponds are in the Area of Institutional Control, also referred to as the “Longterm Surveillance and Institutional Control Area” (Luthiger, 2005) or the “Proposed Withdrawal Area” (Maxim Technologies, 2001).

The underground workings from which the uranium ore was extracted are located north of the mill facility (Figure 2.2). The underground workings are largely interconnected, as shown in Figure 2.2, and include more than 1,000 leach holes, 85 vent holes, and nine mine shafts (NMED, 2007b). Several other former uranium operations are located in the surrounding area. These other uranium operations include the Section 27 Mine and the former Phillips Petroleum Mill site, now the U.S. Department of Energy (DOE) TI (Maxim Technologies, 2001; Figure 2.2). The DOE TI processed uranium ore from Section 27, the Anna Lee, and other nearby mines using an alkaline leach process rather than a sulfuric acid leach process (U.S. DOE, 1996). However, the Rio Algom mill at the Site was the largest milling and tailings facility in the area and is, along with its underground mines, likely the primary source of contaminated groundwater in the area (AVM Environmental Services and Applied Hydrology Associates, 2000; Maxim Technologies, 2001).

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[1] Rio Algom mines were located in the following sections: 17, 19, 22, 24, 30 West, 30 East, 33, 35, and 36 (Rio Algom Mining, 2006).

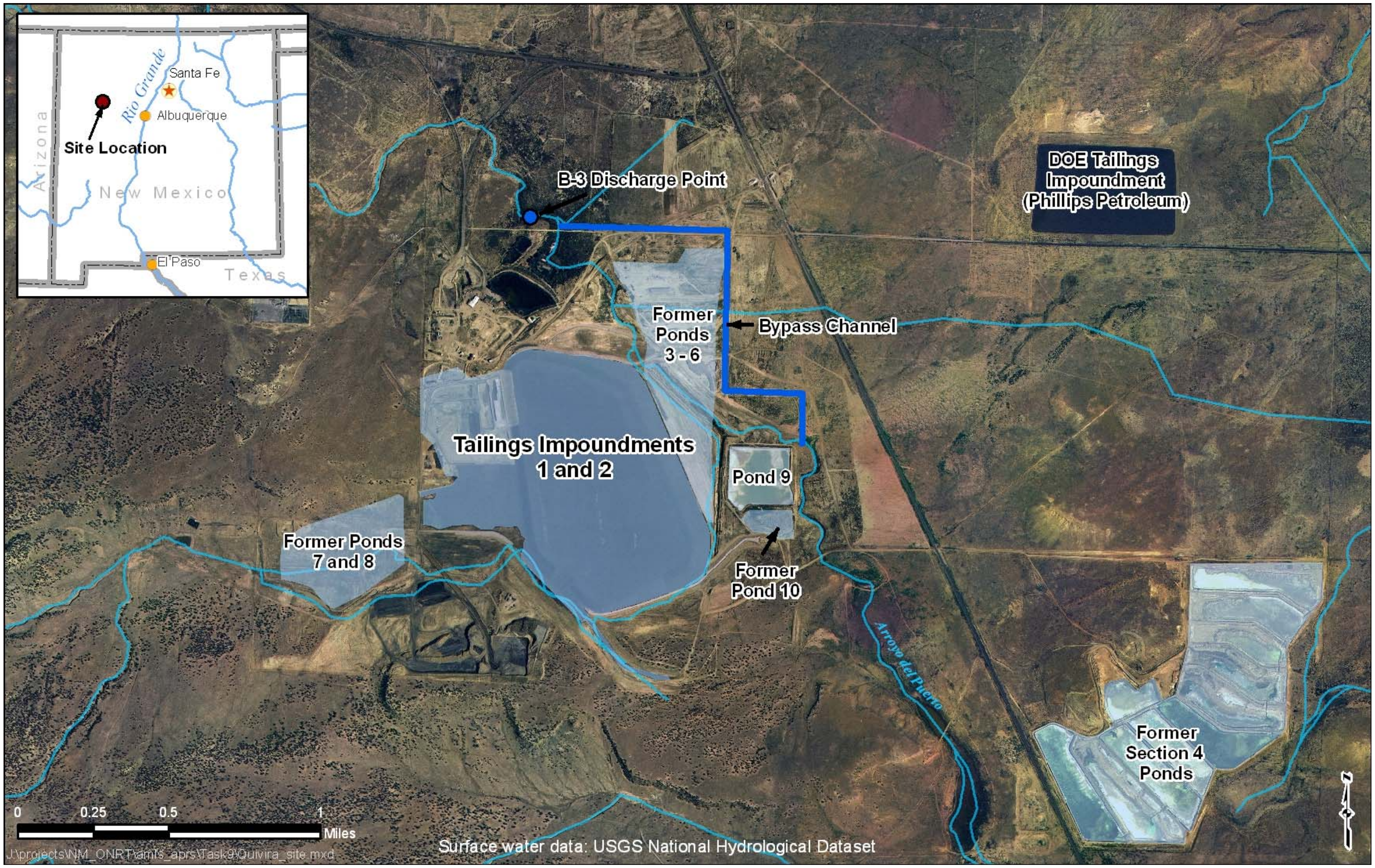

Figure 2.1. Site overview.

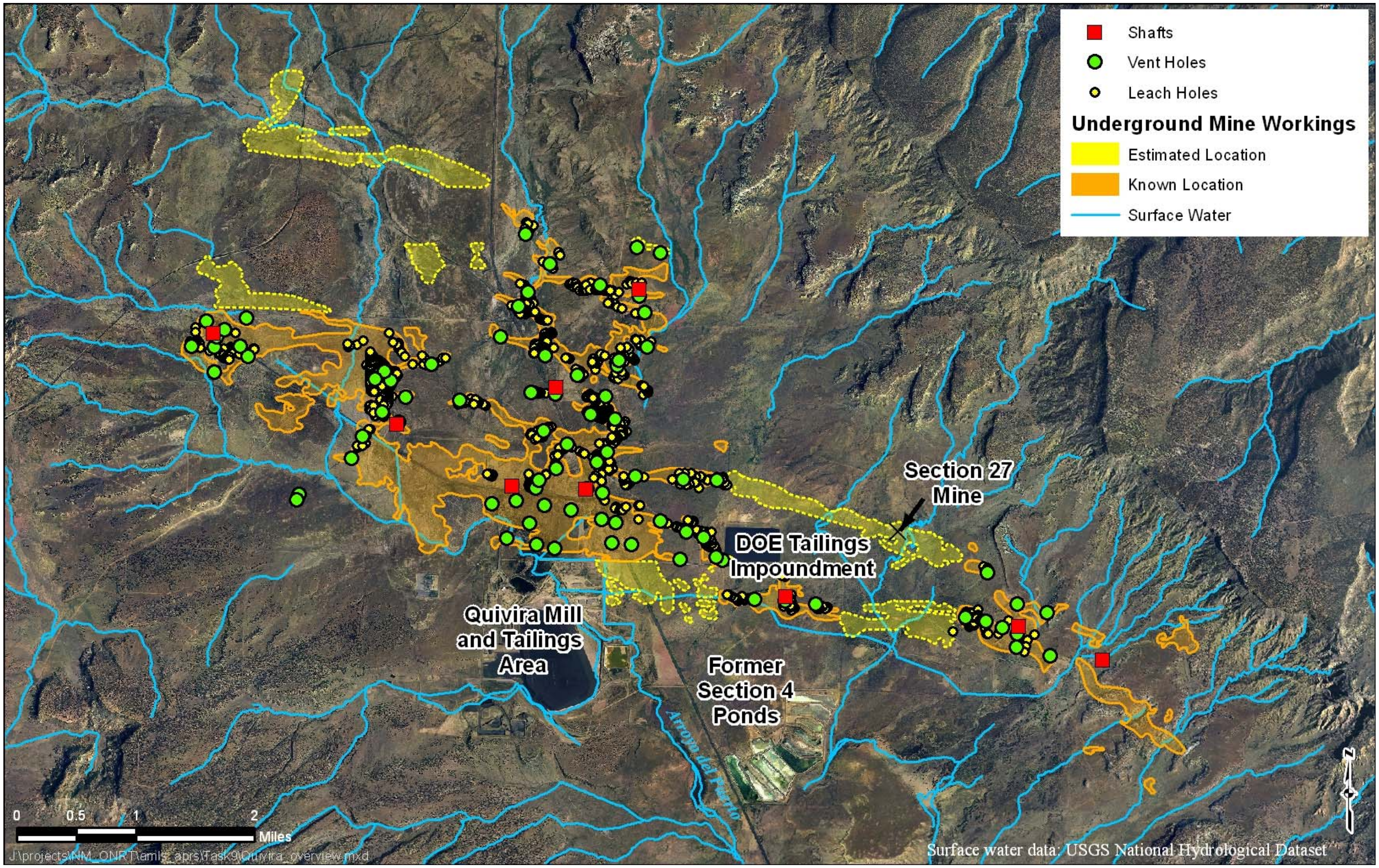

Figure 2.2. Underground mine workings.

2.2 Site History and Mining Process

Kermac Nuclear Fuels Corp., a partnership of Kerr-McGee Oil Industries, Inc., Anderson Development Corp., and Pacific Uranium Mines Co., built the Kerr-McGee mill at Ambrosia Lake in 1957–1958. Quivira Mining Co., a subsidiary of Kerr-McGee Corp., took over operations in 1983. Rio Algom purchased Quivira Mining in 1989, and in 2000, Billiton acquired Rio Algom (Paton, 2000; McLemore, 2007). Billiton merged with BHP in 2001 to form BHP Billiton. The current site operator is Rio Algom Mining LLC, a wholly owned subsidiary of BHP Billiton.

Uranium ore was extracted from underground workings and milled at the Site from 1957 through 1985. During this time, approximately 33 million tons of ore were processed at the mill (Brummett et al., 2006). The mill stopped operating in March 1985. Table 2.1 describes key events in the history of the Site.

Table 2.1. History of the Site

Date	Event	Source
1957	Underground mining begins; evaporation Ponds 4, 5, and 6 constructed.	Maxim Technologies, 2001
1958	TI1 and TI2 and evaporation Pond 3 constructed; first tailings produced.	Maxim Technologies, 2001
1959	First tailings seepage interceptor trench constructed.	AVM Environmental Services and Applied Hydrology Associates, 2000
1960–1975	Use of unlined evaporation Ponds 4, 5, and 6 suspended.	AVM Environmental Services and Applied Hydrology Associates, 2000
1961	Evaporation Ponds 7 and 8 constructed.	Maxim Technologies, 2001
1976	Rio Algom Mining diverts Arroyo del Puerto; following diversion, Ponds 4–6 used again; tailings seepage interceptor trench deepened.	AVM Environmental Services and Applied Hydrology Associates, 2000; Janosko, 2006
1978	Kerr-McGee begins spreading dewatering water on soils, reportedly for irrigation purposes.	INTERA, 2007
1979	Water balance prepared by Quivira Mining Company (QMC); discharge plan for Section 4 evaporation ponds (DP-71) approved in August. Ponds 11–15 constructed; Ponds 16 and 17 constructed in August; Ponds 18–21 constructed in September.	AVM Environmental Services and Applied Hydrology Associates, 2000; NMED, 2004

Table 2.1. History of the Site (cont.)

Date	Event	Source
1983	Milling rate is 3,000 tons/day; investigations in shafts and ventilation holes conducted to determine water elevations and quality in bedrock aquifers; QMC enters Assurance of Discontinuance; discharge to Ponds 4–8 discontinued; ponds drained and reclamation cover emplaced; construction and maintenance of the interceptor trench begins; Discharge Plan for old stope leaching (DP-362) approved in May.	Bostick, 1985; Rio Algom Mining, 2007
1984	Discharges to Pond 3 discontinued; Pond 2 expanded to include tailings dam; tailings seepage interceptor trench excavated to bedrock; discharge plan for the mill (DP-169) approved in March.	Bostick, 1985; AVM Environmental Services and Applied Hydrology Associates, 2000
1985	Mill stops operating in March – on standby until 2003; discharge plan for Section 35 and 36 mines (DP-67) approved in August; full-scale old-stope leaching begins. Dewatering stopped in most mines.	Rio Algom Mining, 2006; Kevin Myers, NMED, personal communication, June 22, 2007
1986	State relinquished licensing authority over uranium milling activities; the Nuclear Regulatory Commission (NRC) requires Site to begin groundwater detection monitoring program.	Maxim Technologies, 2001; Rio Algom Mining, 2007
1989	Site reclamation activities commenced – work on top surface of the largest tailings cell.	U.S. NRC, 2007
1990	Corrective Action Plan approved by NRC; construction of radon barrier cover for TI1 begins; Section 35 Mine ion-exchange facility closed – water piped to Rio Algom Mill.	INTERA, 2007; Kevin Myers, NMED, personal communication, June 22, 2007
1994	Sampling program on Pond 10 begins.	Brummett et al., 2006
1995	Production resumes; dewatering pumping resumed in Sections 19, 24, 35/36, and 30 West mines.	Rio Algom Mining, 2006
1996	Pumping initiated in trenches constructed near TI1.	Quivira Mining, 1998
Mid-/late 1990s	Windblown tailings on the mill site northwest of TI1 and TI2 remediated.	Brummett et al., 2006
1997	QMC initiates alluvial groundwater investigation in area southeast of TI1.	Quivira Mining, 1998
1999	NRC evaluates remediated soils in mill area and finds remediation of soil contaminated by windblown tailings inadequate.	Brummett et al., 2006
2000	Old stope leaching discontinued.	Kevin Myers, NMED, personal communication, June 22, 2007

Table 2.1. History of the Site (cont.)

Date	Event	Source
2002	Active uranium production stops.	U.S. NRC, 2007
2003–2004	Mill decommissioned.	Brummett et al., 2006
2004	Former mill demolished and TI2 closed.	Brummett et al., 2006
2005	Dewatering of all underground mines ended in December.	Rio Algom Mining, 2006
2007	New Mexico uranium groundwater quality standard lowered to 0.03 mg/L for all discharges.	NMED, 2007a
2009	The New Mexico Environment Department (NMED) gives conditional approval of Rio Algom’s Stage 1 Abatement proposal.	NMED, 2009

mg/L = milligrams per liter.

Ponds 4, 5, and 6 were built in 1957 for the evaporation of mine water and mill effluents. TI1 and TI2 were built in 1958, as was Pond 3, which received decant water from TI1 and TI2. A tailings seepage interceptor trench was constructed in 1959 east of Pond 3 to prevent seepage from the unlined TIs and evaporation ponds from reaching the Arroyo del Puerto and infiltrating to alluvium. This trench was deepened in 1976 and in 1984 (AVM Environmental Services and Applied Hydrology Associates, 2000). Evaporation Ponds 7 and 8 were built in 1961. Ponds 3, 4, and 6 were not used from 1960 to 1975. During this time, mine water was diverted to TI1 and TI2 and Ponds 7 and 8. Evaporation Ponds 7 and 8 and TI1 and TI2 generally overlie bedrock, while Ponds 3, 4, 5, and 6 were constructed on alluvium. None of these ponds were lined. In 1976, the Arroyo del Puerto was diverted from its natural course east of Pond 3 to its current location east of Ponds 4, 5, 6, 9, and 10 (Maxim Technologies, 2001).

Starting in 1978, water pumped from underground mines as part of dewatering operations was spread on soils, reportedly for irrigation purposes. NMED determined in 2005 that discharges of mine water from Section 35 and 36 uranium mines were influencing Site conditions (INTERA, 2007). The Section 36 Mine closed in 1984, and all discharges were stopped.

Beginning in 1983, mill effluent and TI decant water were sent to Pond 9, which was lined, and to the lined ponds in Section 4. In addition, TI2 (unlined) was used until 1986, and unlined Pond 3 was used until 1984 (Bostick, 1985).

In addition to underground mining, uranium was extracted from the mine workings using old stope leaching with oxygenated water injected or pumped into the mine. Old stope leaching was first attempted before 1977, and feasibility tests were conducted from 1983 to 1984. The feasibility tests were conducted with sulfuric acid or bicarbonate solutions. Full-scale old stope leaching was conducted from 1985 to January 2000 at ~1,000 gallons per minute (gpm) using over 1,000 two- to three-inch leach holes drilled into the underground workings.

The recovered old stope leach solutions were processed at the mill in an acid-leach circuit (Kevin Myers, NMED, personal communication, June 2007). The recovered leach solution was mixed with sodium chlorate ($NaClO_3$ – a strong oxidizer), ammonia gas, or sodium chloride (NaCl) to precipitate yellowcake uranium. Yellowcake uranium refers to the concentrate produced at mills, and is generally ammonium diuranate [$(NH_4)_2U_2O_7$] or sodium diuranate ($Na_2U_2O_7$) (U.S. Bureau of Mines, 1975; Kerr-McGee Nuclear, Undated).

In 1986, the State relinquished its licensing authority over uranium mill activities to the NRC, which required QMC to begin a groundwater monitoring program (Maxim Technologies, 2001; Rio Algom Mining, 2007). The mine was put on standby in 1986. During this time, uranium was extracted from mine water using the ion exchange units, and the processed mine water was discharged into a drainage channel (Brummett et al., 2006). In the late 1990s, three additional interceptor trenches were constructed to capture seepage missed by the original interceptor trench. One trench was between Ponds 7 and 8, one was between Pond 7 and TI-2, and one extended along the east side of the TIs and Pond 3 (Rio Algom Mining, 2007).

TI1 and TI2 were stabilized and capped beginning in 1990. TI1 was approximately 260 acres and contained 30 million tons of uranium mill tailings. TI2 was approximately 90 acres and contained 3 million tons of uranium mill tailings (AVM Environmental Services and Applied Hydrology Associates, 2000). The tailings covers are evaporation and radon-barrier covers that consist of 3 feet (ft) of Mancos Shale (radon barrier) and basalt or dolomite riprap. Subsurface contamination was not addressed, and vegetation was not established on the covers as part of the remedy.

The surface soils of some evaporation ponds have been reclaimed and revegetated. In windblown tailings areas just northwest of TI1 and TI2, Rio Algom identified areas where the upper few feet of soils were radioactive, removed the contaminated soils, and replaced them with non-radioactive borrow soils in the mid- to late 1990s (Brummett et al., 2006). The mill was on standby from 1985 to 2003 and decommissioned from 2003 to 2004 (Brummett et al., 2006). Also in 1990, an ion-exchange facility at the Section 35 Mine was closed, and Kerr-McGee began piping water from the Section 35 Mine to the Rio Algom Mill (INTERA, 2007).

The NRC evaluated the prior remediation of soils in the mill area in 1999 (Brummett et al., 2006). Their evaluation found that the remediation of soil contaminated by windblown tailings was inadequate (Brummett et al., 2006). The area potentially contaminated by tailings was reported to be 740 acres at the mill area (410 acres with surface contamination from windblown tailings and 330 acres with deeper contamination) and 256 acres near the Section 4 Ponds (Brummett et al., 2006). The contaminants of concern listed in Brummett et al. (2006) are uranium, thorium-230, and radium-226. Rio Algom generally has not thoroughly assessed or addressed other hazardous substances potentially released to soils.

In 1995, the NRC approved Rio Algom's request to construct two disposal areas to receive waste from the TIs as part of closure activities. During subsequent construction of surface water diversion channels, Disposal Area #1 was regraded and capped, making it unavailable for waste disposal. Disposal Area #2, located on the northwestern side of TI 1 and 2 (see Figure 2.1), continues to receive waste materials. Reclamation activities have at times included unlined evaporation pond residue excavation and disposal, contaminated windblown soil cleanup, TI reclamation, surface water erosion protection feature construction, and mill building demolition. Rio Algom has removed lined evaporation pond Number 9 and Numbers 11 through 21 and placed contaminated sediments, dikes, and underlying materials into Disposal Area #2. In 2007, Rio Algom estimated that up to 3 million cubic yards of materials would be excavated, hauled, and compacted as part of the action (Tetra Tech, 2007; U.S. NRC, 2007).

Disposal Area #2 is reaching its capacity and likely will not be sufficient to contain all reclamation materials; Rio Algom recently requested that NRC approve an alternate disposal site, an action that may require NMED to approve an amendment to existing groundwater discharge permits (Olson, 2010; Tetra Tech, 2010).

In addition to the plans from the 1990s, Rio Algom submitted a soil remediation decommissioning plan to the NRC in 2005 (Brummett et al., 2006). Additional remedial activities planned for the surface soils in the mill area include removing the top six inches of contaminated soil. The response plan for deeper contamination includes placing a physical cover and applying institutional controls to restrict access to the contaminated areas (Brummett et al., 2006). The proposed cleanup levels are 5 picocuries per gram (pCi/g) radium-226 above background in the top 6 inches of soil, and 15 pCi/g radium-226 above background in subsurface soils. As mentioned previously, Rio Algom has not addressed other hazardous substances potentially in soils.

The uranium groundwater standard was lowered from 5 mg/L to 0.03 mg/L in 2004. New water discharges needed to meet the standard by September 26, 2004, but it did not apply to past and current (as of September 26, 2004) water discharges until June 1, 2007 (NMED, 2007a).

2.3 Identification of Potentially Responsible Parties

The State of New Mexico has identified Rio Algom/BHP Billiton as the primary potentially responsible party (PRP) for the Site. The term PRP, as used in this document, refers to parties potentially liable for natural resource damages under CERCLA. It is possible that companies other than Rio Algom/BHP Billiton sent ore to the Quivira Mill (now owned by Rio Algom), including Homestake and United Nuclear Corporation (UNC), but at this time the State has concluded that Rio Algom/BHP Billiton is the primary PRP for the Site (Jerry Schoeppner, NMED, personal communication, June 21, 2010).

2.4 Releases of Hazardous Substances

Several reports have documented releases of hazardous substances from the Site and have identified actual or potential sources of these releases.

2.4.1 Hazardous substances released

As described in numerous studies of the Site (e.g., U.S. DOE, 1987; AVM Environmental Services and Applied Hydrology Associates, 2000; Maxim Technologies, 2001; Rio Algom Mining, 2007), hazardous substances released at and from the Site include but are not limited to:

- Ammonia and its degradation products
- Arsenic and compounds
- Beryllium and compounds
- Cadmium and compounds
- Copper and compounds
- Lead and compounds
- Nickel and compounds
- Selenium compounds
- Sulfuric acid and its degradation products
- Radionuclides, including radium, radon, thorium, and uranium
- Zinc and compounds.

2.4.2 Sources of hazardous substance releases

The primary source areas of hazardous substances at the Site are mine and mill process liquids, TIs, evaporation ponds, soils in the mill area, discharged mine water, areas with windblown tailings, and the underground workings.

In addition to the metals in the tailings, soil, and underground workings, hazardous substances from the old-stope leaching operations have been released into the environment. Sulfuric acid, a listed hazardous substance, was used by Rio Algom as a leaching solution in pilot old-stope leaching operations. In addition, sulfuric acid was used at uranium mills like the Quivira Mill in the acid-leach portion of the uranium separation process (U.S. Bureau of Mines, 1975; NMED, 2009; Jerry Schoeppner, NMED, personal communication, June 21, 2010). Sulfuric acid also can cause releases of hazardous metals from the ore. The process solution, which had a low pH (i.e., high concentrations of sulfuric acid), contained elevated concentrations of molybdenum, nickel, radium, selenium, sulfate (SO_4), and uranium (Table 2.2). The mill tailings solution also had high concentrations of SO_4, which is a component of sulfuric acid and therefore results from the release of a hazardous substance [43 CFR § 11.14(v)].

Table 2.2. Hazardous substances and other constituents of concern in mine process liquids and tailings liquids

Constituent	Units	Concentration in process liquids	Concentration in tailings liquids
pH	s.u.	1.1	3.95
Aluminum	mg/L	1,380	722
Arsenic	mg/L	1.6	< 0.6
Cadmium	mg/L	0.3	0.14
Chloride	mg/L	1,540	2,300
Copper	mg/L	2.2	0.47
Iron	mg/L	2,990	1,400
Lead	mg/L	1.0	< 1.2
Lead-210	pCi/L	–	4.5
Manganese	mg/L	120	160
Molybdenum	mg/L	14	0.46
Nickel	mg/L	1.0	1
Radium-226+228	pCi/L	336	62
Selenium	mg/L	6	< 1.2
Sulfate	mg/L	34,600	16,000
Total dissolved solids (TDS)	mg/L	40,800	28,090
Thorium-230	pCi/L	–	11
Uranium	mg/L	11.2	8.4
Vanadium	mg/L	46	8.4
Zinc	mg/L	8.4	7.4

pCi/L = picocuries per liter; s.u. = standard units.

Sources: AVM Environmental Services and Applied Hydrology Associates, 2000; Maxim Technologies, 2001.

Elevated SO_4 concentrations in underground mine water can also be related to the excavation of ore with sulfur-containing minerals or leakage from high ionic strength waters from the overlying Dakota sandstone (Kelly et al., 1980). $NaClO_3$ and NaCl were both used in the processing of the recovered leaching solution, and elevated concentrations of chloride in groundwater at the Site appear to be the result of the use of these chemicals (Maxim Technologies, 2001). Concentrations of nitrate in alluvial groundwater under the former Section 4 Ponds (DP-71) are up to 25 times the federal Safe Drinking Water Act (SDWA) maximum contaminant level (MCL) of 10 mg/L (NMED, 2008b). Nitrate can derive from the use of ammonia to extract uranium from the resins at the mill (NMED, 2009), the use of ammonia for precipitation of uranium from the acid solution by neutralization (U.S. Bureau of Mines, 1975; Kerr-McGee Nuclear, Undated), and/or blasting residue in mine water. Ammonia is a listed hazardous substance, and blasting agents, such as ammonium nitrate and others, are listed hazardous substances because of their characteristic reactivity. Therefore, elevated nitrate concentrations in groundwater could also derive from the release of a hazardous substance.

From the early 1960s to the mid-1980s, uranium mill tailings were used as backfill in underground mines in the Grants Mineral Belt area, including at the Site. Leachate from the mill tailings used as backfill contained high concentrations of aluminum, chloride, uranium, vanadium, arsenic, lead, manganese, sodium, zinc, TDS, nitrate, selenium, gross alpha radioactivity, radium, and sulfate and added to water quality degradation in the underground mine (Jerry Schoeppner, NMED, personal communication, June 21, 2010; Brookins et al., Undated; Longmire et al., Undated; Thomson and Heggen, Undated).

Based on analytes with high concentrations in mining sources at the Site, the hazardous substances released at the Site include, but may not be limited to, arsenic, cadmium, copper, lead, nickel, nitrate (derived from the release of ammonia or blasting agents), radium, selenium, SO_4 (derived from the release of sulfuric acid), thorium, uranium, vanadium (if present as vanadium oxide or vanadyl sulfate), and zinc.

2.4.3 Time, quantity, duration, and frequency of releases

Releases of hazardous substances probably started shortly after mining commenced at the Site in 1957. Since 1980, releases of hazardous substances have likely been ongoing from the following sources:

- TIs
- Evaporation ponds
- Underground mine workings and backfilled tailings
- Arroyo del Puerto sediment
- Leach and vent holes
- Windblown tailings.

Since the end of milling operations, the thickness of contaminated groundwater in the alluvial aquifer at the Site has decreased. Although windblown tailings were remediated in the mid- to late-1990s and again more recently, the efforts only addressed radioactivity in surface soils. Very little characterization of deeper soils and hazardous non-radiologic constituents has taken place on the mill site. The leach and vent holes have been capped but not cemented or plugged. Remedial efforts related to the mill site soils are ongoing, and no remedial efforts have been directed at Arroyo del Puerto (Jerry Schoeppner, NMED, personal communication, June 21, 2010).

2.5 Relevant Operations Occurring at or near the Site

Remediation of the mill area of the Site is ongoing. Rio Algom is addressing contaminated mines primarily under the State abatement process and may be consolidating all the Rio Algom mines under one abatement plan (NMED, 2008a). The remediation under the State process will include all constituents of concern rather than only radiologic constituents. The State remediation process at the mines is in its early assessment stages (Jerry Schoeppner, NMED, personal communication, June 21, 2010). There are no active federal CWA discharge permits at the Site, although there are four active NMED discharge permits: DP-362 for conventional and old stope mining, DP-71 for the former Section 4 evaporation ponds, and DP-67 and DP-264 for Section 35/36 mines.

2.6 Damages Excluded from Liability

The State is not aware of any conditions that qualify damages for exclusion from CERCLA liability [43 CFR § 11.24(b)]. Specifically:

1. **The damages resulting from the releases have not been specifically identified as an irreversible and irretrievable commitment of natural resources in an environmental impact statement or other comparable environmental analysis, no decisions were undertaken by the State to grant permits or licenses authorizing such commitments of natural resources, and PRP facilities were not otherwise operating within the terms of such permits or licenses.** The State is unaware of any permits or licenses that would authorize injuries to natural resources such as terrestrial habitat, surface water, groundwater, and biota. Rio Algom petitioned the NRC for alternate concentration limits (ACLs) for groundwater, and NRC granted the request in 2006 (U.S. NRC, 2006). Rio Algom has not obtained State approval for alternate abatement standards, to satisfy State requirements in cases where groundwater contamination cannot be remediated to applicable standards. The NRC's approval of ACLs does not imply that the groundwater contamination was a permitted release of hazardous substances.

2. **Damages and the releases of hazardous substances from which such damages resulted have not occurred wholly before enactment of CERCLA.** Information reviewed for this preassessment screen indicates that releases of hazardous substances, natural resource injuries, and associated damages have occurred since 1980 and are ongoing.

3. **Damages have not resulted from the application of a pesticide product registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C. §§ 135-135k.** This criterion does not apply to releases from the Site, which do not involve applications of a pesticide product.

4. **Damages have not resulted from any other federally permitted release, as defined in §§ 101(10) of CERCLA.** The State is unaware of any permits or licenses that would authorize injuries to natural resources such as terrestrial habitat, surface water, groundwater, and biota.

3. Preliminary Identification of Resources at Risk [43 CFR § 11.25]

3.1 Preliminary Pathway Identification [43 CFR § 11.25(a)]

As described in Chapter 2, actual or potential source areas of hazardous substances at the Site include mine and mill process liquids, the TIs, evaporation ponds, soils in the mill area, discharged mine water, areas with windblown tailings, Arroyo del Puerto, vent and leach holes, and the underground workings. Hazardous substances deposited on soils or arroyo sediment also can serve as sources when the hazardous substances are mobilized and re-released. Hazardous substances released from sources may be transported to State natural resources by direct contact, surface water and sediments, groundwater, aerial transport, soil, and food chain pathways (Figure 3.1). Pathways of hazardous substance transport at the Site are described briefly in the sections below.

3.1.1 Pathways to groundwater

Groundwater at the Site likely has been exposed to hazardous substances via several pathways, including direct leaching to groundwater from the walls of the underground mines and backfilled tailings, infiltration of seepage from tailings and evaporation ponds, and infiltration of discharged mine water and process fluids to groundwater. Seepage from tailings and evaporation pond sources and discharged mine water has infiltrated to the underlying alluvium (Bostick, 1985). For example, QMC estimated that in 1979 the total seepage rate from unlined ponds to groundwater was 203 gpm (AVM Environmental Services and Applied Hydrology Associates, 2000). Seepage from a process water pond, discharge of mine water to Site soils from the Section 35/36 mines, and seepage from tailings have artificially recharged groundwater in the alluvium and the upper, weathered portion of the Mancos Shale (U.S. DOE, 1991).

All contaminated groundwater at the Site ultimately derived from bedrock groundwater pumped from the underground mines, or from the infiltration of precipitation through contaminated materials. During active mining, water was pumped from the underground mines and either used in the mine processes or discharged to drainages or the ground surface. This water likely became contaminated as a result of mining and came to be located in part in the alluvial aquifer on the Site. Prior to mining, little alluvial groundwater may have been present at the Site (Maxim Technologies, 2001). After pumping slowed and eventually stopped, water levels in the underground mines began to rise again but were still exposed to hazardous substances as rising water levels dissolved metal salts from the walls of the underground workings. Therefore, essentially two volumes of groundwater became contaminated as a result of mining activities: the

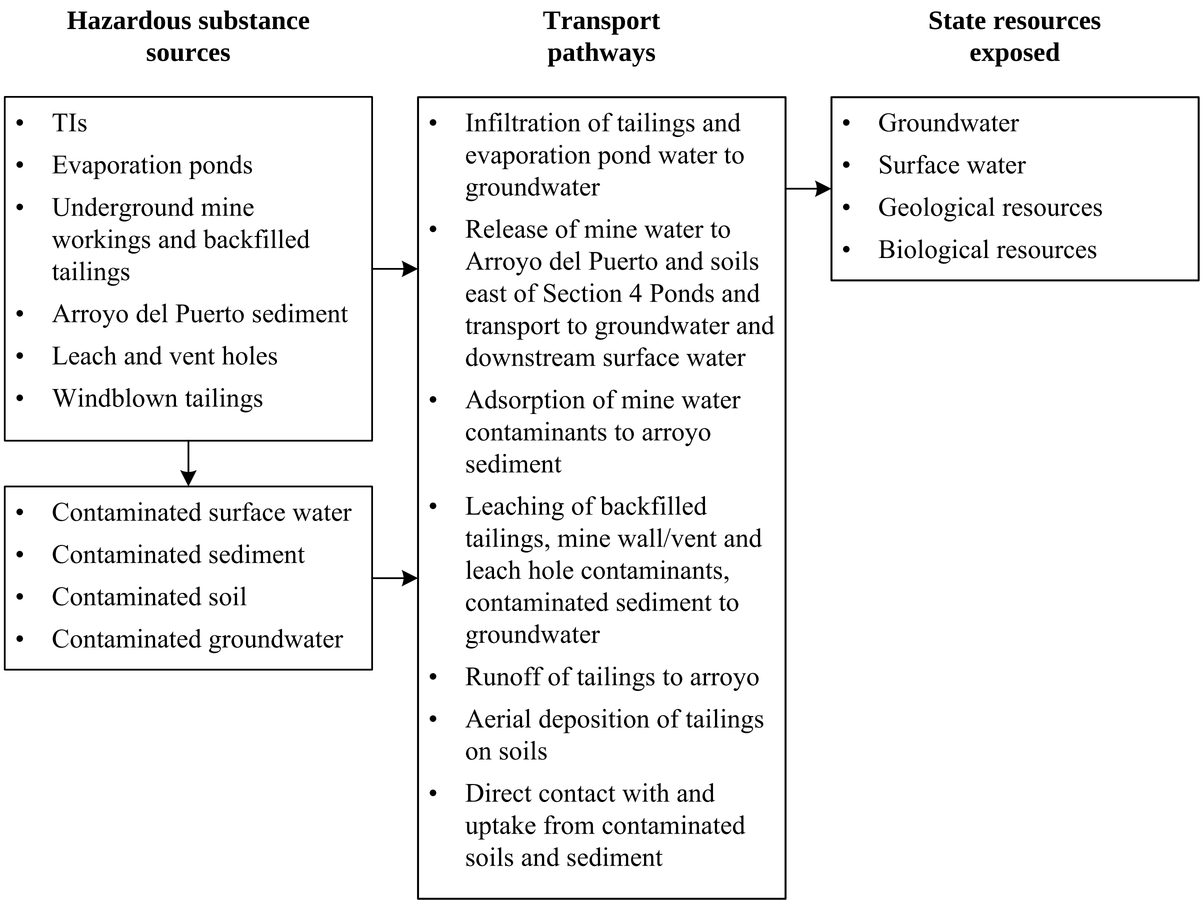

Figure 3.1. Preliminary identification of pathways by which State resources may be exposed to hazardous substances from the Site.

amount pumped out of the mines during mining, and the amount that filled up the underground mines after active mining stopped.

Although most of the evaporation ponds have been remediated, contaminated seepage from these ponds is likely present in the vadose zone as salts, metals, metalloids, and other contaminants. Infiltration of rainwater also can result in continuing releases of hazardous substances under the former evaporation pond areas, as the remediation did not address non-radioactive hazardous substances. Seepage from the tailings area is likely an ongoing source of hazardous substances to groundwater, and the mine shafts, vents, and leach holes will likely continue to leach hazardous substances to bedrock groundwater. As water levels rise in the underground workings, metal salts will likely continue to dissolve and contaminate inflowing clean groundwater.

3.1.2 Pathways to surface water/sediment

During storm events before the tailings were capped, runoff would have carried tailings to West Arroyo and the Arroyo del Puerto, where they would have been deposited as sediment. Historically, both treated and untreated mine water was also discharged directly into the Arroyo del Puerto, contaminating the arroyo and its sediment and causing infiltration of contaminated water to the alluvial aquifer (AVM Environmental Services and Applied Hydrology Associates, 2000). Downstream transport of contaminants in surface water and sediment, and downgradient movement in the alluvial aquifer serve as other potential pathways.

3.1.3 Pathways to soils

Soils can be exposed to hazardous substances through direct deposition or aerial deposition. Aerial deposition of windblown tailings or contaminated soils serves as a likely pathway of contamination to surface soils in the area (Brummett et al., 2006). Hazardous substances from tailings may be transported to and deposited on soils during dry months with high winds. Aerial redistribution of these contaminated soils through wind erosion may also occur.

Terrestrial biota, aquatic biota, and surface water resources at the Site may be exposed to hazardous substances that are transported through aerial deposition. These pathways are described more fully in the following section.

3.1.4 Pathways to vegetation and biota

Terrestrial biota may come in direct contact with hazardous substances through dermal, inhalation, and ingestion exposure to windblown tailings and other mine waste at the ground surface.

Biota in arroyos may come in direct contact with hazardous substances through exposure to contaminated surface water, direct contact with contaminated sediment (e.g., macroinvertebrates), and exposure to hazardous substances via the food chain pathway.

Soils that have been exposed to hazardous substances either through aerial transport or directly from deposited mine waste can provide a pathway of exposure to vegetation, terrestrial biota, aquatic biota, and surface water resources. Terrestrial vegetation may be exposed to hazardous substances in soil through root uptake. Terrestrial wildlife may be exposed to hazardous substances in soil through dermal contact, uptake, and ingestion.

Organisms also could be exposed to hazardous substances via a food chain pathway, in which prey organisms accumulate hazardous substances in their tissues, and predators are subsequently exposed to these contaminants when they consume the prey.

Finally, hazardous substances may impair the viability of habitats to support the needs (e.g., food, cover) of biological resources.

3.2 Exposed Areas and Estimates of Concentrations [43 CFR § 11.25(b)]

This section presents examples, based on a review of readily available information, of concentrations of hazardous substances that have been measured in natural resources of the Site. This information is not intended to be a comprehensive review of all studies that have been conducted at the site. Rather, this section presents examples drawn from a rapid review of the readily available literature. Concentrations of other hazardous substances that are not discussed in this section may be, and in some cases are known to be, elevated at the Site as well.

3.2.1 Groundwater

The DOI regulations define groundwater resources as:

> Water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which ground water moves. It includes ground water resources that meet the definition of drinking water supplies [43 CFR § 11.14(t)].

The major geologic units at the site are Quaternary alluvium in the Arroyo del Puerto streambed (Figure 3.2) and sedimentary formations of Cretaceous and Jurassic age. The Quaternary alluvium is characterized by tan to gray silts, sands, gravels, and some sandstone cobbles and boulders. The alluvium ranges in thickness from a thin layer to over 100 ft (Purtyman et al., 1977). In order of increasing depth from the surface, the sedimentary units are Mancos shale, Tres Hermanos sandstone (C, B, and A units), Dakota sandstone, all of Cretaceous age (Figure 3.2), and the three Morrison Formation units of Jurassic age: Brushy Basin, Westwater Canyon, and Recapture (Figure 3.3). The Westwater Canyon member of the Morrison Formation is the ore-bearing unit and is characterized by fine- to coarse-grained, poorly sorted, cross-bedded sandstone with local conglomerate and chert lenses. The Westwater Canyon unit contains extensive deposits of uranium and vanadium ore and is also the principal aquifer in the region (Purtyman et al., 1977; Kelly et al., 1980).

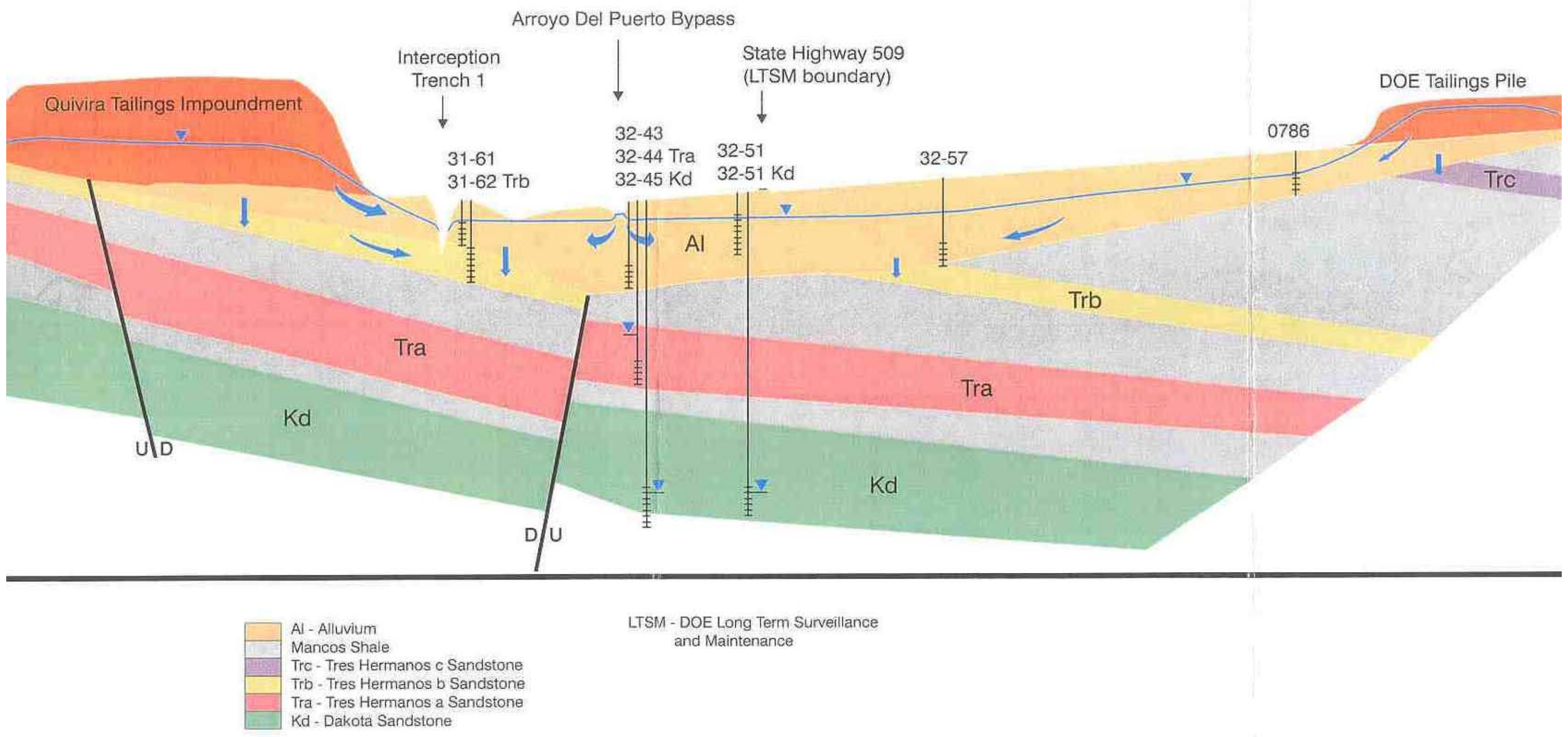

Figure 3.2. Geologic cross-section at the Site.

Source: Maxim Technologies, 2001.

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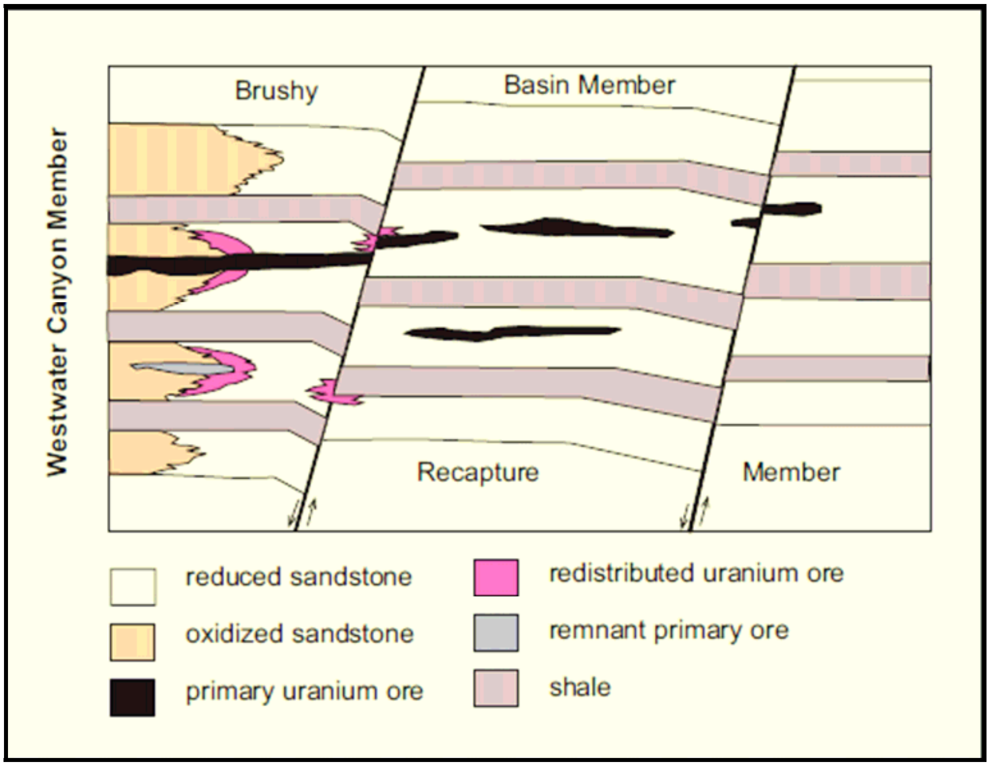

Figure 3.3. Uranium deposits in the Morrison Formation

Source: McLemore, 2007, Figure 2.

Bedrock groundwater in the area of the Site flows north-northeast toward the San Juan basin (Kelly et al., 1980), while alluvial groundwater generally flows to the south (Maxim Technologies, 2001). Prior to mining, the alluvium was most likely unsaturated; discharge of mine dewatering water and seepage from the TI and evaporation ponds saturated the alluvium and the weathered Mancos shale and dewatered the underlying bedrock (Bostick, 1985; U.S. DOE, 1991; Kevin Myers, NMED, personal communication, June 7, 2007). Wells in the alluvium/weathered Mancos shale and the Tres Hermanos-C sandstone produce 150 gallons per day or less. The Tres Hermanos-C sandstone is only basally saturated and received most of its recharge from the overlying alluvium and weathered Mancos shale (U.S. DOE, 1991). Table 3.1 summarizes the hydrologic properties of the major geologic units at the Site.

Table 3.1. Summary of geologic characteristics

Formation	Thickness (ft)	Depth below surface (ft)	Hydraulic gradient (ft/ft)	Porosity	Hydraulic conductivity (ft/day)
Alluvium	20–109.9	20–110	0.007–0.025	0.15–0.25	0.6–20
Mancos shale	258.9–518	279–540			
Dakota sandstone	60–79	358–611	0.037–0.034	0.03	0.4
Tres Hermanos A sandstone	38.2		0.007		
Tres Hermanos B sandstone	36.7		0.042–0.023	0.05	0.8
Tres Hermanos C sandstone[a]			0.025		0.8
Morrison Formation					
Brushy Basin member	95.8–171.9	513–1,355	0.026	0.007[b]	1.2
Westwater Canyon member	145–195.2	909–1,500			
Recapture member	84–147	821–1,004			

a. Only under the former Phillips Mill/Ambrosia Lake TI; see Figure 2.1.

b. Storage coefficient (Purtyman et al., 1977, p. 8).

Sources: Purtyman et al., 1977; Kelly et al., 1980; U.S. DOE, 1991; AVM Environmental Services and Applied Hydrology Associates, 2000; Maxim Technologies, 2001; Janosko, 2006.

Bedrock groundwater

Data for the underlying bedrock units show evidence of exposure to hazardous substances from mining-related activities. Mean concentrations of SO_4, uranium, radium-226, and selenium from uranium mines in nine sections over a 47-year period (1958 to 2005) are shown in Table 3.2. Underground mining, and later leaching activities, were conducted at the nine section mines generally north of the mill site and the TI area. Uranium ore from the section mines was transported to the mill for processing and disposal in the TI area (Kevin Myers, NMED, personal communication, June 7 and 22, 2007). The nine section mines associated with the Site are shown in Figure 2.2. Each of these mines extracted ore from the same formation (Morrison Formation).

The results in Table 3.2 show the presence of hazardous substances[1] in deep groundwater at the Site. Figure 3.4 shows concentrations of uranium in groundwater increasing over the course of mining. Concentrations generally peaked in the mid-1980s, possibly associated with the use of old stope mining methods. Concentrations of sulfate, radium, and selenium in deep groundwater also increased after mining began (NMED, 2007b).

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[1] As discussed in Section 2.4.2, sulfate derives from the release of a hazardous substance.

Table 3.2. Mean[a] concentrations of sulfate, uranium, radium-226, and selenium in deep groundwater in section mines, 1958 to 2005

Section mine	Sulfate (mg/L)	Uranium (mg/L)	Ra-226 (pCi/L)	Selenium (mg/L)
17	699	7.1	40.6	0.07
19	1,210	8.8	67.7	0.09
22	732	11.0	50.8	0.31
24	1,150	23.1	114	0.38
30	1,570	8.8	66.5	0.12
30W	1,540	7.0	88.4	0.12
33	1,680	7.8	28.5	0.03
35	805	6.8	125	0.07
36	709	0.98	64.0	0.02
Overall mean	1,122	9.0	71.7	0.13

a. For calculating the mean, the detection limit was used for values below detection.

Source: NMED, 2007b.

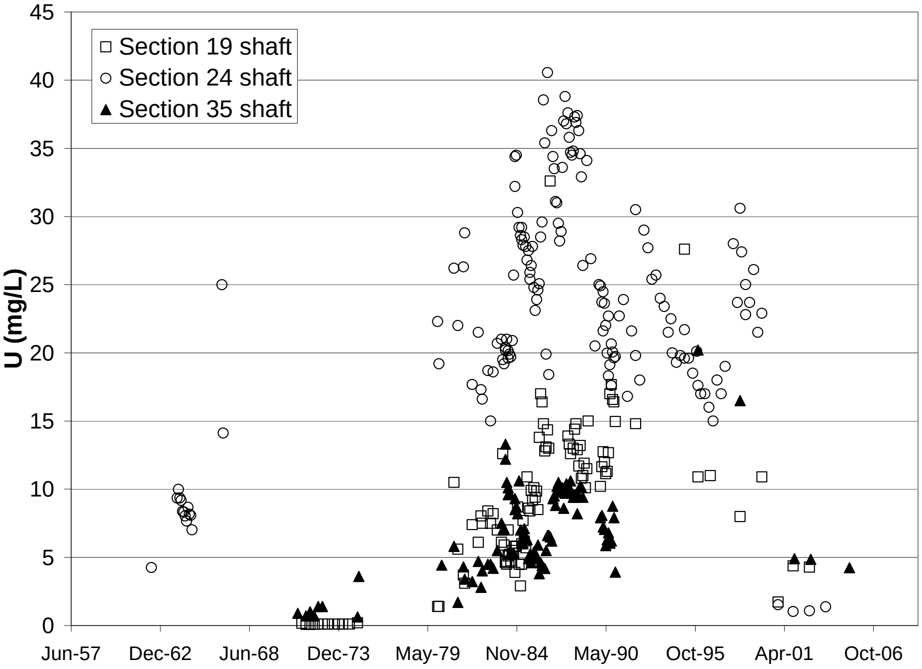

Figure 3.4. Uranium concentrations in Sections 19, 24, and 35 mine shafts from the early 1960s to 2005. The federal and State drinking water standard for uranium is 0.03 mg/L; the State standard was 5 mg/L prior to June 1, 2007 (NMED, 2007a).

Data source: NMED, 2007b.

Alluvial groundwater

Elevated concentrations of mining-derived hazardous substances are also present in alluvial groundwater, including elevated concentrations of SO_4, lead-210, uranium, radium, selenium, thorium, and gross alpha emissions (data received from NMED, 2007b). Table 3.3 contains mean, minimum, and maximum values for SO_4, pH, and radionuclides in alluvial groundwater. Figure 3.5 shows widespread elevated SO_4 concentrations in alluvial wells throughout the Site.

Table 3.3. Contaminant concentrations in alluvial groundwater

	TI area, 1999–2005			Former Section 4 Ponds area, 1987–2007		
Analyte	**Mean**	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**
Sulfate (mg/L)	2,480	< 10	10,700	2,430	80	6,180
pH	7.9	3.0	10.5	7.1	6.2	8.0
Uranium (mg/L)	0.3	< 0.001	3.75	0.1	0.01	0.29
Gross alpha (pCi/L)	135	0	820	–	–	–
Radium-226 (pCi/L)	3.8	0.2	78	–	–	–
Radium-228 (pCi/L)	1.1	0	7.4	–	–	–

Source: NMED, 2007b. Not all data are included.

3.2.2 Surface water

Surface water in the area is limited primarily to ephemeral streams and washes. The principal surface water body at the Site is the Arroyo del Puerto, an ephemeral stream that runs south-southeast through the Site (see Figure 2.1) and joins San Mateo Creek approximately five miles to the south. Before mining at the Site began, the arroyo probably contained flowing surface water after storm events, but no measurements of flow are available from this period. Bostick (1985) conducted a flooding analysis for the 100-year storm and the probable maximum precipitation (PMP) reoccurrence interval storm for Arroyo del Puerto and the West Arroyo, which is located west of the TI and contains former evaporation Ponds 7 and 8. The modeled PMP in Arroyo del Puerto was a six-hour storm with a peak flow of 128,100 cubic feet per second (cfs). Although the PMP was found to not pose a threat to the mill or tailings areas from Arroyo del Puerto, PMP flows in the West Arroyo would overtop the diversion ditch and come in contact with the tailings. The State Engineer calculated that a one-hour peak flow for a PMP in the West Arroyo is 12,000 cfs (Bostick, 1985). These predicted flows are very large and indicate the likely presence of surface water during storm events in West Arroyo and Arroyo del Puerto.

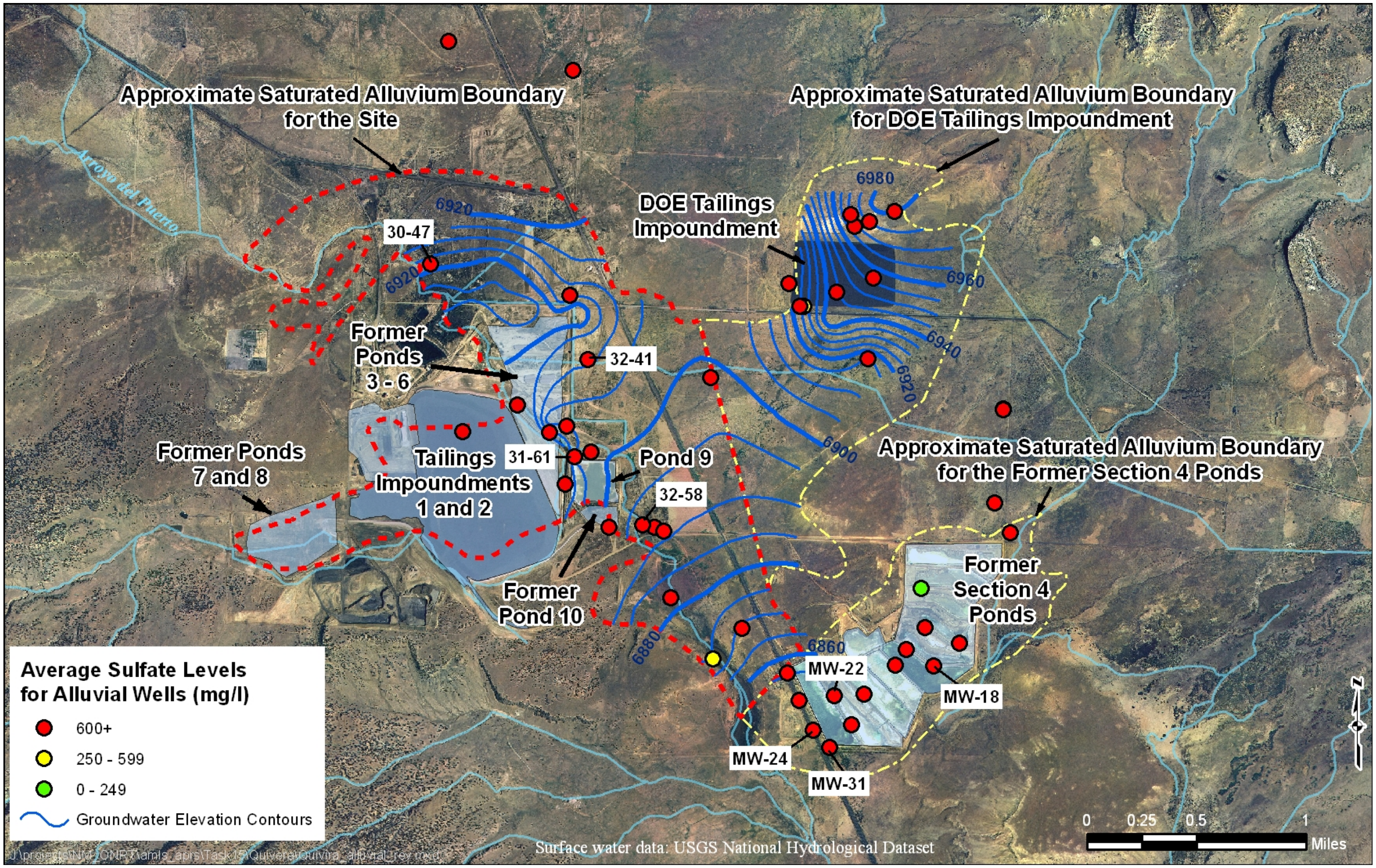

Figure 3.5. Sulfate concentrations in alluvial wells at the Site and estimated areal extent of saturated alluvium for different parts of the Site.

Sources: Maxim Technologies (2001), Figure 2-17; Luthiger (2005); NMED (2007b).

Once mining began, the three major sources of water in the Arroyo del Puerto (in addition to stormwater flows) were pumped mine water discharged directly to the stream, seepage from the make-up reservoir, and seepage from the tailings and evaporation ponds (Bostick, 1985). The discharges from the mine to the arroyo caused it to be perennial and, along with leakage from the TI and evaporation ponds, contributed to the increased saturated thickness in the alluvium resulting from mining (Bostick, 1985). According to the water balance performed for the Site in 1979, approximately 290 gpm of wastewater were added to the Arroyo del Puerto from seepage and direct discharge (Bostick, 1985). Beginning in 1983, use of the unlined ponds ended, and wastes were diverted to lined Pond 9 and to the lined ponds in Section 4; however, TI2 (unlined) was used until 1986, and unlined Pond 3 was used until 1984 (Bostick, 1985).

Limited surface water data from the Site are available. Kerr-McGee Nuclear (1981) collected surface water samples from the Arroyo del Puerto in 1980 (Table 3.4). Sample P-1 was collected upstream of the TI, T-1 and T-2 were taken from the arroyo close to the TI, and P-8 through P-15 were taken progressively farther downstream in the Arroyo del Puerto (Kerr-McGee Nuclear, 1981). The data in Table 3.4 indicate likely exposure of surface water resources to selenium, molybdenum, radium-226, and other contaminants.

Table 3.4. Water quality in the Arroyo del Puerto, 1980. Sample P-1 was collected upstream of the TI, T-1 and T-2 were taken from the arroyo close to the TI, and P-8 through P-15 were taken progressively downstream in the Arroyo del Puerto.

Analyte	P-1	T-1	T-2	P-8	P-10	P-12	P-14	P-15
Sulfate (mg/L)	950	990	960	970	1,010	940	890	940
Chloride (mg/L)	90	150	120	130	140	180	180	190
TDS (mg/L)	1,710	1,750	1,730	1,730	1,710	1,710	1,760	1,830
Selenium (mg/L)[a]	0.074	0.1	0.05	0.066	0.061	0.061	0.062	0.05
Molybdenum (mg/L)	0.71	0.75	0.71	0.63	0.48	0.52	0.64	0.55
Radium-226 (pCi/L)	5	2	3	2	24	3	7	9

a. Total recoverable selenium.

Source: Kerr-McGee Nuclear, 1981.

The U.S. Environmental Protection Agency (U.S. EPA) collected surface water samples in Arroyo del Puerto downstream of the former Kerr-McGee mill in 1975. Radium-226 concentrations ranged from 45 to 50 pCi/L, uranium concentrations ranged from 5 to 12 mg/L, and gross alpha emissions ranged from 1,400 to 1,700 pCi/L. Miles downstream, near the mouth of Arroyo del Puerto, values of gross alpha were as high as 1,500 pCi/L, radium-226 as high as 7.2 pCi/L, and uranium as high as 6.6 mg/L (U.S. EPA, 1975). Average selenium concentrations were 0.15 m/L downstream of the mill and 0.04 mg/L near the mouth of Arroyo del Puerto. According to U.S. EPA (1975), most of the water in lower Arroyo del Puerto infiltrated to groundwater near the San Mateo Creek confluence, potentially contaminating alluvial groundwater downstream and downgradient of the Site.

3.2.3 Terrestrial resources

Terrestrial resources include soils (geologic resources), vegetation, and biota. DOI NRDA regulations define geologic resources as those elements of the Earth's crust such as soils, sediments, rocks and minerals . . . that are not included in the definitions of ground and surface water resources [43 CFR § 11.14(s)]. Biological resources are defined as those natural resources referred to in Section 101(16) of CERCLA as fish and wildlife and other biota [43 CFR § 11.14(s)].

The majority of the Ambrosia Lake Valley is classified as Great Basin grasslands. The grasslands support several wildlife species. The U.S. Fish and Wildlife Service (USFWS) has documented the following threatened and endangered species in McKinley County: bald eagle (*Haliaeetus leucocephalus*), black-footed ferret (*Mustela nigripes*), Mexican spotted owl (*Strix occidentalis lucida*) with critical habitat, southwestern willow flycatcher (*Empidonax traillii extimus*), and the rhizome Zuni fleabane (*Erigeron rhizomatus*). However, no habitat for these listed species has been identified at the Site (U.S. NRC, 2007).

Available data show that soils in the vicinity of the mill, TI, and east of the former Section 4 Ponds, and sediment in the evaporation ponds at the Site, are or have been contaminated with hazardous substances, including uranium-238, thorium-230, and radium-226 (Brummett et al., 2006; INTERA, 2007). Tailings piles and windblown tailings were remediated in the mid-1980s and 1990s. The NRC conducted confirmatory sampling in 1999 and found that remediation goals had not been met (Brummett et al., 2006). Rio Algom has completed additional remediation efforts to address the remaining radioactive soil contamination at the Site (Brummett et al., 2006), but the non-radioactive components and deeper contamination have not been addressed (Jerry Schoeppner, NMED, personal communication, June 21, 2010).

Figure 3.6 shows areas of the Site with soils that may have been exposed to hazardous substance releases. A brief review of contaminant concentrations in specific areas follows.

Sediment and soils in the former evaporation ponds (Ponds 3 to– 10, and the former Section 4 Ponds prior to the most recent remedial actions) have been contaminated by releases of radionuclides at the Site (information for Ponds 4 to 10 is contained in Table 3.5). Sample averages from the upper 15 centimeters (cm; 0.5 ft) of Ponds 4, 5, 6, 8, and 10 (no surface samples were collected from Pond 7) ranged from 5.8 to 20 pCi/g radium-226. Thorium-230 concentrations were elevated in Ponds 4, 5, 6, 7, 8, and 10, as well as in the former Section 4 Ponds (Table 3.5). Similarly, concentrations of uranium-238 were elevated in Ponds 4, 5, 6, 7, 8,

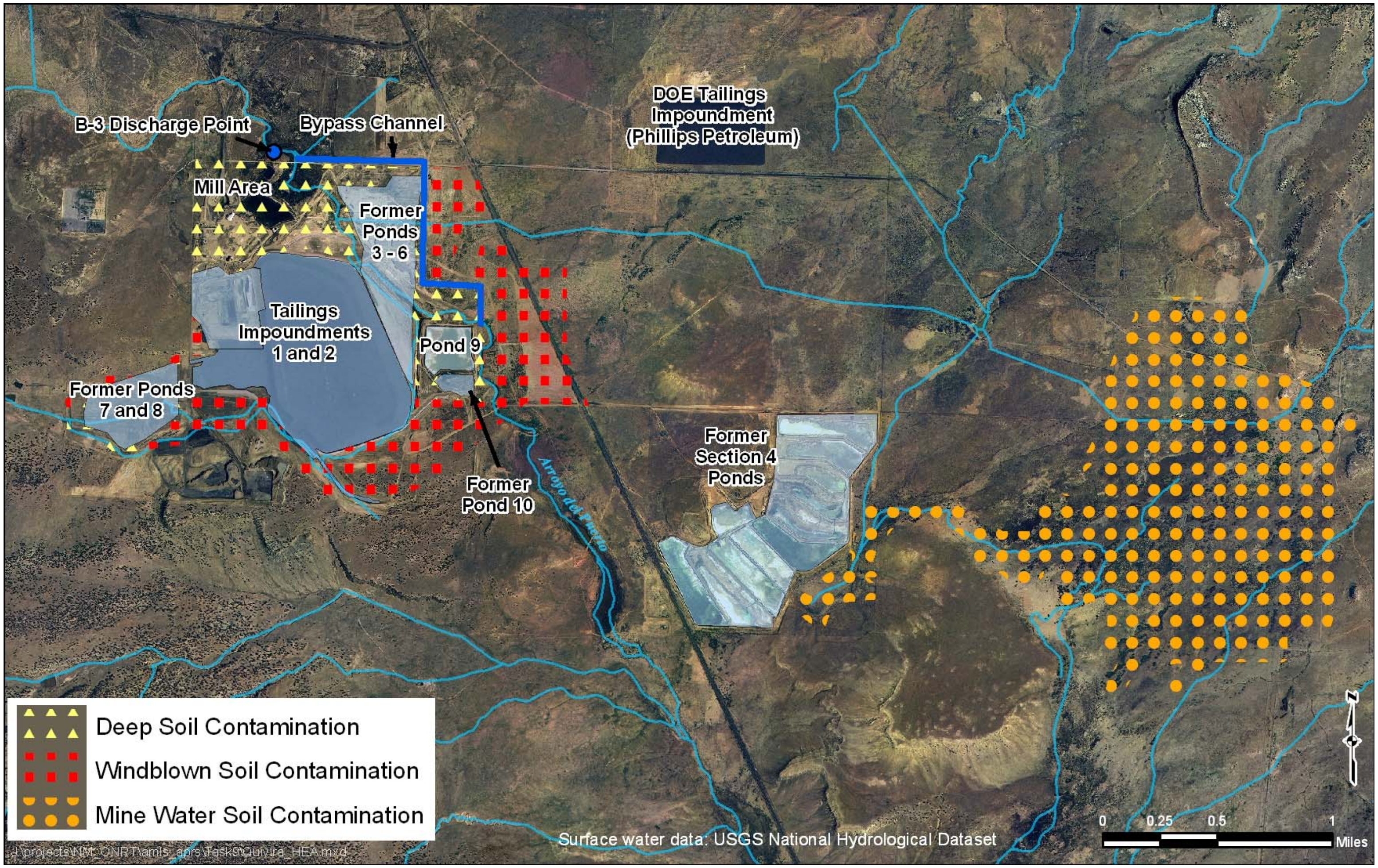

Figure 3.6. Areas where mining activities have potentially impacted soils at the Site.

Sources: Komex, 2004, Figure 1-3; INTERA, 2007, Appendix B, Figure 3.3-1.

Table 3.5. Average concentrations of radioactive constituents in sediment from former evaporation ponds, tailings, and areas with windblown tailings. It is likely that non-radioactive constituents are also elevated.

			Pond 10[b]				
Analyte (units)	**Ponds 4 and 5[a]**	**Ponds 6, 7, and 8[a]**	**0–0.5 ft (0–15 cm) depth**	**0.5–1 ft (15–30 cm) depth**	**Former Section 4 Ponds[c, d]**	**Quivira Mill tailings sands[a]**	**Site windblown tailings[a, d]**
Radium-226 (pCi/g)	20 (range 2 to 62)	12 (range 0.5 to 78)	5.8	10.5	31.3	1,400	6.78
Gamma exposure rate (μR/hr)	–	–	14.5	26.3	78.3	–	–
Gamma (cpm)[e]	–	–	–	–	–	–	42,292[e]
Thorium-230 (pCi/g)	1,380 (range 1 to 4,470)	485 (range 0.1 to 2,070)	509.6	1,412.8	820.9	240	9.72
Uranium-238 (pCi/g)	11 (range 1 to 68)	8.4 (range 0.9 to 51)	30.3	1.4	–	20.9	1.50

Notes:
Conversion from pCi/g to micro-Roentgens per hour (μR/hr): 2.5 μR/hr per pCi/g (U.S. DOE, 1991).
Conversion from pCi/g to milligrams per kilogram (mg/kg): 0.67 to 1.5 picocuries per microgram (pCi/μg) (U.S. EPA, 2000a).

a. Komex, 2004, Tables 2-4, 2-6, 2-8, 2-9, 2-10, 3-3.
b. Brummett et al., 2006.
c. Tetra Tech, 2007, Tables 9.5 and 9.6.
d. Data collected prior to the most recent remedial activities.
e. Mean natural background in soils is 17,807 counts per minute (cpm); Komex, 2004, Table 3-3.

and 10 (Table 3.5; Komex, 2004; Brummett et al., 2006; Tetra Tech, 2007). The association of selenium and other hazardous substances with uranium in source areas at the Site suggests that non-radioactive hazardous substances are likely to be elevated as well, but no concentration data for these constituents in sediment or soil are available.

Releases from the TIs (TI1 and TI2) have exposed State geologic resources (soils) to radionuclides. Data from a single sample of tailings sand contained 1,400 pCi/g of radium-226, 240 pCi/g of thorium-230, and 20.9 pCi/g of uranium-238 (Table 3.5). Windblown tailings contaminated soils near the mill site with radionuclides, including uranium, thorium-230, and radium-226 (Brummett et al., 2006). A soil sample from windblown tailings deposition area at the Site contained 6.78 pCi/g radium-226, 9.72 pCi/g thorium-230, and 1.5 pCi/g uranium-238 (Komex, 2004). It is likely that non-radioactive hazardous substances were also released to soils.

Soils potentially affected by process solution and mine water discharge

An area near the former mill (Figure 3.6) has deep soil contamination related to the release of process fluids from the mill (Komex, 2004). Remediation of this area included removal of the contaminated surface soils, placement of a physical barrier to minimize radiation from deeper soils, and placement of institutional controls to limit access (Brummett et al., 2006).

Soils at the Site have also been exposed to hazardous substances as a result of discharges of mine waters from Section 35/36 mines to an area east of the former Section 4 Ponds (Figure 3.6; INTERA, 2007). Contaminant concentrations in soil leachate (Tables 3.6 and 3.7) and in soils (Tables 3.8 and 3.9) collected east of the former Section 4 Ponds indicate that geologic resources have been exposed to and potentially injured by releases of radionuclides, metals, and metalloids from the Site. The high concentrations of hazardous substances in leachate samples suggest that soil could also serve as a pathway for contamination of underlying groundwater.

Table 3.6. Concentrations of radium and uranium in soil leachate (water percolated through soils) from east of the former Section 4 Ponds

Depth below surface	Radium-226 (pCi/L)		Sum of Ra-226 and Ra-228 (pCi/L)		Uranium (mg/L)	
	Maximum	**Average**	**Maximum**	**Average**	**Maximum**	**Average**
0–1 ft	270	23.9	276.5	25.6	0.23	0.03
1–2 ft	1.1	0.3	6.8	2.3	0.4	0.06
2–4 ft	0.97	0.225	3.9	1.8	0.31	0.07
4–6 ft	0.81	0.31	3.11	2.19	0.11	0.03
10–12 ft	0.49	0.17	2.29	0.94	0.02	< 0.01

Source: INTERA, 2007. To calculate average, the detection limit was used for values below detection.

Table 3.7. Concentrations of arsenic, molybdenum, and selenium in soil leachate (water percolated through soils) from east of the former Section 4 Ponds

Depth below surface	Arsenic (mg/L)		Molybdenum (mg/L)		Selenium (mg/L)	
	Maximum	Average	Maximum	Average	Maximum	Average
0–1 ft	0.007	0.003	0.1	0.03	0.020	0.007
1–2 ft	0.0031	0.0011	0.90	0.08	0.250	0.026
2–4 ft	0.0026	0.0011	0.33	0.09	0.113	0.026
4–6 ft	0.0014	0.0011	0.16	0.04	0.057	0.018
10–12 ft	0.0023	0.0013	0.08	0.02	0.210	0.053

Source: INTERA, 2007. To calculate average, the detection limit was used for values below detection.

Table 3.8. Concentrations of radium, uranium, and arsenic in soils from east of the former Section 4 Ponds

Depth below surface	Radium-226 (pCi/g)		Uranium (mg/kg)		Arsenic (mg/kg)	
	Maximum	Average	Maximum	Average	Maximum	Average
0–1 ft	14	5.4	22.7	11.6	10.8	6.1
1–2 ft	18	2.2	67.5	16.1	10.6	6.4
2–4 ft	3.2	0.86	35.1	11.8	9.2	6.0
4–6 ft	6.5	2.86	19.1	9.0	9	6.0
10–12 ft	0.7	0.3	12	2.5	7.9	3.7

Source: INTERA, 2007. To calculate average, the detection limit was used for values below detection.

Table 3.9. Concentrations of molybdenum, selenium, and vanadium in soils from east of the former Section 4 Ponds

Depth below surface	Molybdenum (mg/kg)		Selenium (mg/kg)		Vanadium (mg/kg)	
	Maximum	Average	Maximum	Average	Maximum	Average
0–1 ft	12	4.7	15.1	2.7	43.2	23.2
1–2 ft	38	5.0	15.3	1.6	54	21.5
2–4 ft	14	2.9	4.3	1.2	45	20.5
4–6 ft	5	1.6	3.86	1.2	34	22.8
10–12 ft	5	2.1	0.99	0.3	36.6	15.7

Source: INTERA, 2007. To calculate average, the detection limit was used for values below detection.

3.3 Potentially Affected Resources [43 CFR § 11.25 (e)(1)]

The data presented in this chapter and in the following chapter support the conclusion that natural resources for which the State has trusteeship have been potentially affected by releases of hazardous substances from Site mining and milling activities. Potentially affected resources include, but are not limited to:

- Alluvial and bedrock groundwater resources and aquifer materials at and downgradient of the Site
- Surface water resources in West Arroyo and Arroyo del Puerto
- Geological resources (soils) in, adjacent to, and downwind of TIs and evaporation ponds
- Terrestrial biological resources.

3.4 Preliminary Estimate of Potentially Affected Services [43 CFR § 11.25(e)(2)]

Services provided or potentially provided by the resources identified in Section 3.3 include, but are not limited to, the following:

- Past, current, and future water for consumption, irrigation, livestock, and other uses
- Terrestrial habitat for wildlife, including food, shelter, breeding and rearing areas, and other factors essential to long-term survival
- Ephemeral aquatic habitat
- Consumptive and non-consumptive outdoor recreation, including hunting, hiking, wildlife viewing, and photography
- Passive use and option values
- Other ecological and biological services provided by natural resources.

4. Determination Criteria [43 CFR § 11.23(e)]

This chapter presents an evaluation of the preassessment determination criteria [43 CFR § 11.23(e)]. The information presented and summarized in this chapter confirms the following:

- A release of hazardous substances has occurred
- Natural resources for which the State has trusteeship potentially have been adversely affected by releases of hazardous substances
- The quantity and concentration of the released hazardous substances are sufficient to potentially cause injury
- Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost
- Response actions will not sufficiently remedy the injury to natural resources without further action.

The evaluation criteria for these conclusions are presented below.

4.1 A Release of Hazardous Substances Has Occurred

Multiple studies and data collection efforts have demonstrated that multiple releases of hazardous substances have occurred and continue to occur as a result of operations at the Site (Section 2.4). Hazardous substances released include, but may not be limited to, arsenic, beryllium, cadmium, copper, lead, nickel, selenium, zinc, and radionuclides (including radium, radon, thorium, and uranium). Although the full scope of environmental exposure to hazardous substances is not yet known, investigators have documented that elevated concentrations of hazardous substances in groundwater, soils, sediments, and surface water have resulted from releases of hazardous substances at the site.

4.2 Trust Natural Resources Have Been Adversely Affected by the Release

Although the full nature and extent of natural resource injuries at the site is not yet known, existing data indicate that natural resources [as defined in 43 CFR § 11.14(z)] for which the State has trusteeship have been adversely affected by releases of hazardous substances. These natural resources include, but are not necessarily limited to, groundwater, surface water, and geological and biological resources, including supporting habitat for State biological resources. This finding is confirmed by the evidence of extensive contamination of State resources with hazardous substances at concentrations sufficient to potentially cause injury, as described below.

4.3 The Quantity and Concentration of the Released Hazardous Substances Are Sufficient to Potentially Cause Injury

4.3.1 Groundwater

The DOI regulations include the following definition for injury to groundwater:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411-1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before the release [43 CFR § 11.62(c)(1)(i)].

An initial evaluation of potential injuries to groundwater can be undertaken by comparing measured concentrations of hazardous substances to federal MCLs, secondary maximum contaminant levels (SMCLs), or State of New Mexico groundwater standards (NMED, 2007a). Table 4.1 summarizes these standards for selected hazardous substances and associated by-products that have been measured at the Site. For contaminants for which New Mexico standards are set at higher concentrations than the federal standard, we compare concentrations to the federal standard.

In the previous chapter, we presented concentrations of contaminants in bedrock groundwater (see Table 3.2), including concentrations of uranium, radium-226, and selenium from Rio Algom/BHP Billiton uranium mines in nine sections over a 27-year period (1971 to 1998). We also showed that concentrations of these constituents in groundwater in the underground mines increased as mining progressed. As shown in Figure 2.2, the underground workings associated with these mines, and therefore groundwater in the mines, are largely interconnected. Here, we compare these concentrations of SO_4, uranium, radium-226, and selenium to federal water quality criteria (Table 4.2). The mean concentrations of SO_4, radium-226, and uranium exceed water quality standards at every section mine, suggesting ubiquitous contaminant sources at the Site. The average concentration across all samples exceeds the federal water quality criteria for all four hazardous substances.[1] The average uranium concentration exceeds the current water quality standard by over two orders of magnitude, and the average radium-226 concentration

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[1] As discussed in Section 2.4.2, sulfate derives from the release of a hazardous substance.

Table 4.1. State of New Mexico and federal water quality standards used to evaluate potential groundwater injury

Analyte	Units	State of New Mexico[a]	Federal SDWA[b]
Lead	mg/L	0.05	0.015
Nickel	mg/L	0.2[c]	–
Selenium	mg/L	0.05	0.05
Sulfate	mg/L	600[d]	250[e]
Radium 226 + 228	pCi/L	30	5
Uranium	mg/L	0.03[f]	0.03
Gross alpha	pCi/L	–	15
pH	s.u.	6–9[d]	6.5–8.5[e]

a. New Mexico human health-based standard (NMED, 2007a) unless otherwise noted.
b. Federal MCL unless otherwise noted.
c. New Mexico secondary standard (standard for irrigation use).
d. New Mexico secondary standard (other standard for domestic water supply).
e. Federal SMCL.
f. New Mexico standard was 5 mg/L until 2004; new sources were required to meet the new standard (0.03 mg/L) by September 26, 2004. The standard went into full effect for all sources on June 1, 2007.

Sources: NMED, 2007a; U.S. EPA, 2010a.

Table 4.2. Comparison of mean[a] concentrations of sulfate, uranium, radium-226, and selenium for Ambrosia Lake uranium mines, 1958 to 2005, to water quality standards

Section mine	Sulfate (mg/L)	Uranium (mg/L)	Ra-226 (pCi/L)	Selenium (mg/L)
17	699	7.1	40.6	0.07
19	1,210	8.8	67.7	0.09
22	732	11.0	50.8	0.31
24	1,150	23.1	114	0.38
30	1,570	8.8	66.5	0.12
30W	1,540	7.0	88.4	0.12
33	1,680	7.8	28.5	0.03
35	805	6.8	125	0.07
36	709	0.98	64.0	0.02
Overall mean	1,122	9.0	71.7	0.13
Federal standard[b]	250	0.03	5 (Ra-226 + Ra-228)	0.05

a. For calculating the mean, the detection limit was used for values below detection.
b. U.S. EPA, 2010a.

Data source: NMED, 2007b.

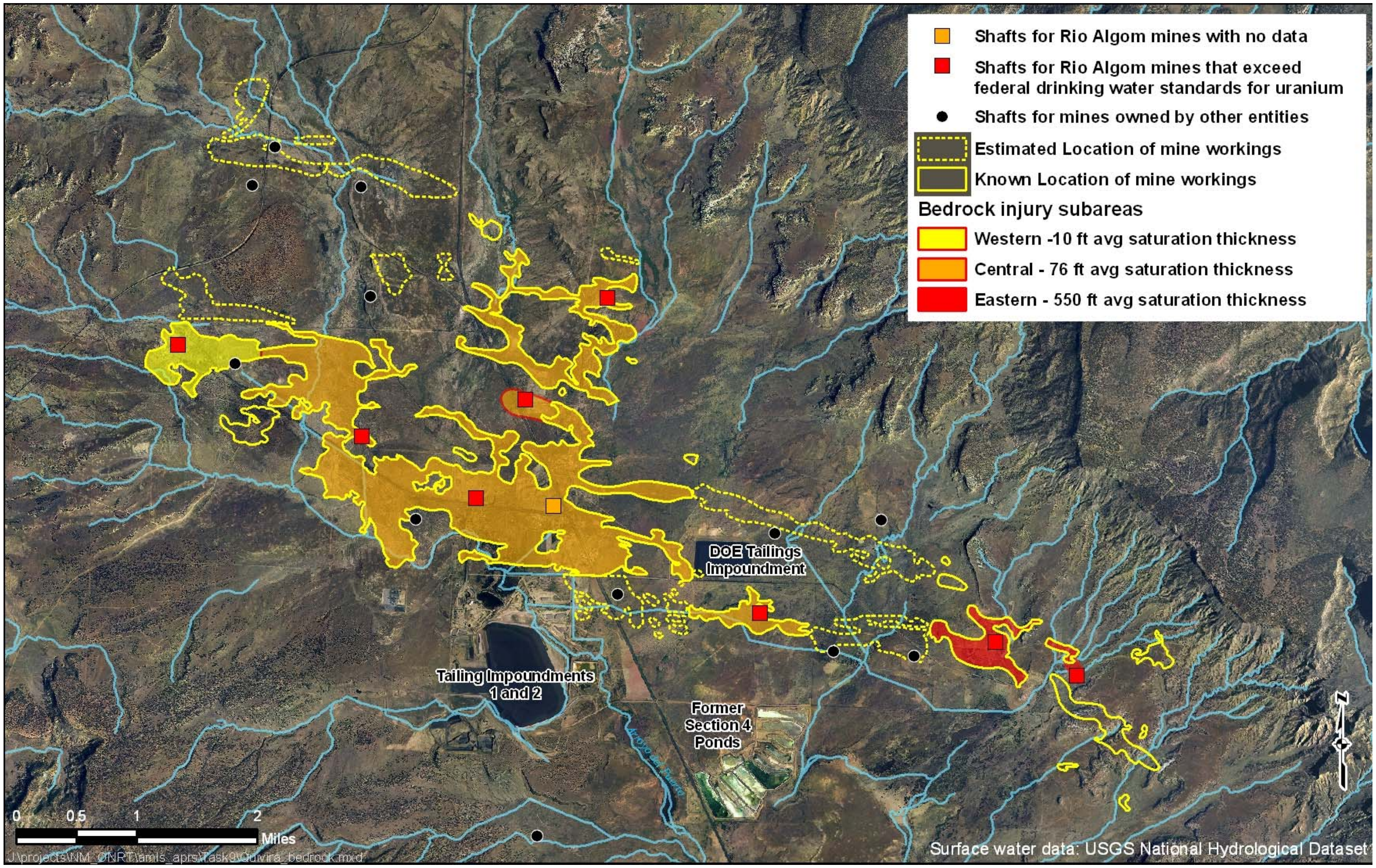

Figure 4.1. Uranium exceedences in bedrock groundwater near the Site in western, central, and eastern portions of the bedrock groundwater.

exceeds the water quality standard by over one order of magnitude (Table 4.2). These data suggest that releases at the Site have been sufficient to potentially cause injury to groundwater resources over a widespread area (Figure 4.1).

Existing data suggest that contaminants in bedrock groundwater collected from mine shafts are the result of releases from mining operations. Uranium concentrations over time show a pattern of increasing concentrations after mining commenced, maximum concentrations after old-stope leaching began in the mid-1980s, and decreasing concentrations after old stope leaching stopped in 2000 (see Figure 3.3).

As discussed in Chapter 3, little alluvial groundwater may have existed at the Site prior to the onset of mining. Infiltration of mine water in Rio del Puerto, unlined evaporation ponds, and the TIs likely introduced contaminated water from mining activities to the alluvial aquifer at the Site. We presented example alluvial groundwater contaminant concentrations in the previous chapter (see Table 3.3). The concentrations of SO_4, uranium, radium, and gross alpha emissions in alluvial groundwater samples exceed federal drinking water standards (Table 4.3). The mean SO_4 concentrations exceed the federal standard by an order of magnitude, and maximum SO_4 concentration exceeds the federal standard over 40 times. Similarly, in alluvial groundwater in the TI area, the mean uranium concentration exceeds the federal standard by an order of magnitude, and the maximum concentration exceeds the standard by two orders of magnitude. The maximum gross alpha and radium concentrations exceed federal standards by at least an order of magnitude (Table 4.3).

Table 4.3. Comparison of contaminant concentrations in alluvial groundwater to water quality standards

	TI area, 1999–2005			Former Section 4 Ponds area, 1987–2007			
Analyte	**Mean**	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**	**Federal standard**[a]
Sulfate (mg/L)	2,480	< 10	10,700	2,430	80	6,180	250
pH	7.9	3.0	10.5	7.1	6.2	8.0	6.5 to 8.5
Uranium (mg/L)	0.3	< 0.001	3.75	0.1	0.01	0.29	0.03
Gross alpha (pCi/L)	135	0	820	–	–	–	15.0
Radium-226 (pCi/L)	3.8	0.2	78	–	–	–	5 (Ra-226 + Ra-228)
Radium-228 (pCi/L)	1.1	0	7.4	–	–	–	

a. U.S. EPA, 2010a.

Data source: NMED, 2007b. Not all data are included.

Potability of groundwater prior to releases

Groundwater quality data from the Site area are generally available from as early as the mid-1970s (Thompson, 2004) and are often reported as representing "background" groundwater quality, even though by that time groundwater had been exposed to releases from mining operations for approximately 20 years. The large number of mines in the area makes it difficult to identify a nearby area with groundwater that has not been impacted by uranium mining operations. Dewatering for mining activities caused a cone of depression in the Westwater Canyon unit, which allowed water from the upper bedrock units (Dakota sandstone and Tres Hermanos A and B units) to seep through vent and leach holes and mine shafts, potentially adding salts to the groundwater (Kelly et al., 1980; Bostick, 1985; Thompson, 2004). Nevertheless, three lines of evidence suggest that groundwater was potable prior to mining at the Site.

First, although based on limited data, wells (rather than mine workings) in the Westwater Canyon member have good water quality. The data presented in Table 4.4 are a summary of water quality data from the U.S. Geological Survey taken from two wells completed in the Westwater Canyon member near Ambrosia Lake (Thompson, 2004). Samples were collected from the two wells on five dates from 1959 to 1988. The wells are in the same formation as the ore body (Kevin Myers, NMED, personal communication, June 2007). Trace metal concentrations, all measured in micrograms per liter (µg/L), were determined in samples from one of the wells in 1987. Mean concentrations of all constituents met State and federal water quality standards (Table 4.4), indicating that the water is potable.

Table 4.4. Historic Westwater Canyon member analytical results (µg/L)

Analyte	Mean	Federal standard[a]
Nitrate (mg/L)	2.27	10
Arsenic	< 1	10
Beryllium	< 0.5	4
Cadmium	< 1	5
Chromium	< 1	100
Copper	< 1	1,300
Lead	< 5	15
Mercury	< 0.1	2
Nickel	3	–
Selenium	< 1	50
Silver	< 1	100

a. U.S. EPA, 2010a.

Data source: USGS, 2007.

Second, a water sample collected from the Section 32 Mine shaft in February 1958, less than one year after mining began, showed low concentrations of SO_4, chloride, and TDS, but somewhat elevated radium values (Table 4.5). Subsequent samples from the Section 32 Mine shaft in the 1970s and 1980s showed that water quality had severely degraded after years of mining (NMED, 2007b). By contrast, concentrations of Site contaminants in groundwater from a well in the vicinity of but unaffected by the Section 23 Mine shafts have remained at or below water quality standards over time (Table 4.5), suggesting that mining caused the degradation of water quality in the Section 32 Mine. Overall, the data in Table 4.5 suggest that water quality in the bedrock was potable absent the release of mining-related contaminants.

Table 4.5. Concentrations of selected contaminants in the Section 32 Mine shaft and the Section 23 well

Location	Date	SO_4 (mg/L)	Cl (mg/L)	TDS (mg/L)	U (mg/L)	Ra-226 (pCi/L)	Se (mg/L)
Section 32 Mine shaft	Feb-58	123	6	426		42	
	Mar-72	2,460	41	4,034	0.04		
	May-72	2,380	51	3,818	0.02		
	Mar-77	1,624	233		1.50	117	0.038
	Mar-83	1,277	18	2,214	14.60	113	0.14
Section 23 well	Nov-65	140	8	457	0.17		
	Aug-98	190	15	360	0.04	5.6	0.005
	Jun-05	190	12	390	0.07	5.1	0.027
Federal drinking water standards[a]		250	250	500	0.03	5 (Ra-226+228)	0.05

a. U.S. EPA, 2010a.

Data source: NMED, 2007b.

Finally, the Westwater Canyon member historically had the highest quality water in the region and provided domestic water supplies prior to mining operations. The Westwater contained somewhat elevated TDS and SO_4 concentrations, although these parameters do not determine potability because they are secondary standards that address aesthetic concerns. Kelly et al. (1980, p.314) stated, “The Westwater Canyon is an artesian aquifer which yields moderate to large amounts of good-quality water to wells . . . Several municipal wells at Crownpoint tap the Westwater Canyon, as do stock and domestic wells throughout the San Juan Basin.” Statements from several sources (Purtyman et al., 1977; Kelly et al., 1980; Bostick, 1985; MWH, 2003; Kevin Myers, NMED, personal communication, June 22, 2007) suggest that water in the Westwater Canyon unit was potable and of good quality and that it was used as a domestic water supply aquifer prior to the onset of mining.

4.3.2 Surface water

The DOI regulations present a number of definitions of injury for surface water resources. These definitions of injury to surface water include the following:

- Concentrations of hazardous substances exceeding SDWA or other relevant federal or state criteria or standards for drinking water [43 CFR § 11.62(b)(1)(i)]
- Concentrations and duration of substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria . . . in surface water that before the discharge or release met the criteria and is a committed use . . . as a habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].

Both the State (NMWQCC, 2002; [20.6.4 NMAC]) and the federal government (U.S. EPA, 2010b) have promulgated water quality standards. The criteria that are designated to protect aquatic life are generally referred to as aquatic life criteria (ALC). The acute criterion is an estimate of the highest concentration of a substance in surface water to which an aquatic community can be exposed briefly without an unacceptable effect. The chronic criterion is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without an unacceptable effect [63 FR 68364, December 10, 1998].

As described in Chapter 3, surface water near the Site comprises ephemeral streams and washes, including Arroyo del Puerto and the West Arroyo. When the mines were operating, contaminated mine waters were discharged directly to the arroyos, in quantities sufficient to make Arroyo del Puerto become perennial (Bostick, 1985; AVM Environmental Services and Applied Hydrology Associates, 2000). During storm events before the tailings were capped, runoff would have carried tailings to the arroyos, where they would have been deposited as sediment.

At this time, the State is not aware of any water or sediment samples collected from the arroyos outside of the water samples from Arroyo del Puerto that Kerr-McGee Nuclear (1981) collected in 1980 (see Table 3.4) and U.S. EPA collected in 1975 (U.S. EPA, 1975) presented in Chapter 3. Each of the 1980 Kerr-McGee samples exceeded the chronic water quality criterium for selenium. In 1975, each of the samples collected downstream of the Site exceeded the water quality criterion for selenium as well. In addition, uranium, radium-226, and gross alpha concentrations exceeded current SDWA groundwater quality criteria by orders of magnitude downstream of the Site, and remained above these criteria miles downstream at the mouth of Arroyo del Puerto (U.S. EPA, 1975). Although these data predate CERCLA, they suggest that surface waters were potentially injured. Surface water and sediment quality in the arroyos remains a data gap.

4.3.3 Terrestrial resources

As described in Chapter 3, terrestrial resources include both geological resources (e.g., soils) and terrestrial biological resources. Eleven injury definitions for geological resources are presented in the DOI regulations. Some definitions that may be relevant to the Site include the following:

- Concentrations of substances sufficient to cause a toxic response to soil invertebrates [43 CFR § 11.62 (e)(9)]
- Concentrations of substances sufficient to cause a phytotoxic response such as retardation of plant growth [43 CFR § 11.62 (e)(10)]
- Concentrations of substances sufficient to have caused injury to surface water, groundwater, air, or biological resources, when exposed to geologic resources [43 CFR § 11.62 (e)(11)].

In addition, the DOI regulations define injury to biological resources as:

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following changes in viability: death, disease, behavioral abnormalities, cancer, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].

In addition to injuries caused by hazardous substance releases, trustees may also recover damages for “any increase in injuries that are reasonably unavoidable as a result of response actions taken or anticipated” [43 CFR § 11.15(a)(1)]. As discussed below, response actions at the site have adversely affected terrestrial habitat, and much of that habitat is not expected to be restored.

To evaluate potential injuries to plants or wildlife, we compare measured concentrations of uranium and selenium in soils at the Site to U.S. EPA ecological soil screening levels (Eco-SSLs), other ecological risk benchmarks. In addition, we compare uranium soil concentrations to calculated soil screening levels (SSLs) meant to protect underlying groundwater from exceeding groundwater quality standards if the uranium infiltrates from soil to groundwater (Table 4.6).

Uranium concentrations in soils east of the former Section 4 Ponds have been measured as high as 67.5 mg/kg, with average concentrations near the surface of 12 mg/kg (see Table 3.8). These concentrations exceed the Efroymson et al. (1997) benchmark for phytotoxicity of uranium-238 in soils (5 mg/kg) by up to 13 times, indicating a potential injury to soil resources. No measured values of uranium-238 in soils exceed the Sheppard et al. (2005) literature-based no-effect

Table 4.6. Soil benchmark or screening level concentrations for the protection of plants, biota, and groundwater

Contaminant	Plants (mg/kg)	Soil invertebrates (mg/kg)	Birds (mg/kg)	Mammals (mg/kg)	SSL for migration to groundwater[d] (pCi/g)
Uranium	5[a], 250[b]	100[b]	NA	NA	0.012, 0.24
Selenium[c]	0.52	4.1	1.2	0.63	NA

a. Uranium-238 screening benchmark for phytotoxicity (Efroymson et al., 1997).

b. Literature-based predicted uranium no-effect concentration for terrestrial plants or soil invertebrates (Sheppard et al., 2005).

c. Eco-SSLs (U.S. EPA, 2007).

d. U.S. EPA, 2000b. The U.S. EPA uranium-238 SSL is a calculated uranium-238 concentration which, if exceeded, would put the underlying aquifer at risk of exceeding uranium groundwater standards. The calculated SSL depends on a dilution/attenuation factor (DAF), the factor by which adsorption, dilution, and other mechanisms can diminish the uranium concentration during transport from soil to groundwater. A low DAF of 1 yields a SSL of 0.012 pCi/g, and a high DAF of 20 yields a SSL of 0.24 pCi/g.

NA = not available.

concentrations for plants or soil biota (250 and 100 mg/kg, respectively; Table 4.6). Average uranium-238 concentrations in the ponds were as high as 30.3 pCi/g in the surface of former Pond 10 and ranged from 9.7 to 11 pCi/g in former Ponds 4, 5, 6, 7, and 8 (Komex, 2004; Brummet et al., 2006). These concentrations exceed U.S. EPA's SSLs for migration to groundwater by over three orders of magnitude, assuming a DAF of 1, and over two orders of magnitude, assuming a DAF of 20 (Table 4.6; U.S. EPA, 2000b).

Selenium concentrations in the upper two feet of soils east of the former Section 4 Ponds averaged over 2 mg/kg and were as high as 15 mg/kg (see Table 3.9). The concentrations near the surface were substantially higher than concentrations at depth, indicating deposition as a likely source. The average concentrations in the upper two feet exceed three of four Eco-SSLs, and the maximum concentrations exceed all four Eco-SSLs by at least a factor of three (Tables 3.9 and 4.6). These data indicate potential injury to terrestrial habitat resources.

As discussed previously, the assessment and remediation of soils at the Site have focused primarily on reducing radioactivity at the surface in selected areas. Soil contaminant data for other contaminants of concern and at other locations at the Site are not available at this time. In general, it would be expected that other hazardous substances would be co-located with radionuclides in soils exposed to Site releases. Because remedial activities are not addressing co-located hazardous substances, geologic resources with hazardous substance concentrations potentially sufficient to cause injury to State trust resources may be extensive.

An evaluation of the response actions taken at the Site indicate a high likelihood that these actions have resulted in reasonably unavoidable injuries to terrestrial resources. Trenches, roads, and waste disposal cells have been constructed to respond to radionuclide contamination at the site; Rio Algom has submitted a proposal to create another waste disposal cell (Tetra Tech, 2010). As discussed in Chapter 2, waste disposal cells and other areas created or remediated in response to radionuclide releases are covered with multiple feet of Mancos shale and capped with either basalt or dolomite riprap, with no vegetation. Such areas may be geographically extensive and are likely to provide little or no terrestrial habitat in perpetuity. Thus, terrestrial habitat potentially injured by response actions may be substantial.

4.4 Data Sufficient to Pursue an Assessment Are Available or Likely to be Obtained at Reasonable Cost

Data relevant to conducting an assessment of natural resource damages at the Site have been collected as part of monitoring and remedial assessment activities at the Site. Such data include information on hazardous substance sources, releases, pathways, and concentrations in the environment. Additional data collection efforts are ongoing as part of the remedial planning process. As noted in Chapter 1, reasonable cost is defined in the DOI regulations as meaning that "the Injury Determination, Quantification, and Damage Determination phases have a well-defined relationship to one another and are coordinated . . . and the anticipated cost of the assessment is expected to be less that the anticipated damage amount" [43 CFR § 11.14 (ee)]. Although the specific elements of injury determination, quantification, and damage determination have not yet been developed for this Site, ONRT does not anticipate difficulties in developing a well-defined and coordinated process. ONRT believes that additional data collection for groundwater and other trust resources could be conducted at reasonable cost, as defined in the regulations.

4.5 Response Actions Will Not Sufficiently Remedy the Injury to Natural Resources without Further Action

Response actions to date have not been sufficient to remedy the potential past, present, and ongoing future injuries at the Site. As shown previously, concentrations of hazardous substances continue to exceed relevant injury thresholds, sometimes by orders of magnitude, particularly in groundwater resources. The NMED has indicated that remedial efforts at the Site aimed at addressing concerns of the NRC do not necessarily address the contaminants of concern identified by the State. Further, response actions do not compensate the State for any past injuries or damages. Finally, as noted above, an evaluation of the response actions taken at the Site indicate a high likelihood that these actions have resulted in injuries to terrestrial resources.

Overall, response actions will not remedy all injuries and compensate the State for losses without further action.

4.6 Conclusions

Based on an evaluation of the preassessment determination criteria, the State has reached the following conclusions for the Site:

- A release of hazardous substances has occurred
- Natural resources for which the State has trusteeship have been adversely affected
- The quantity and concentration of the released hazardous substances are likely to cause or to have caused injury
- Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost
- Response actions will not sufficiently remedy the injury to natural resources without further action.

Based on an evaluation of these five criteria, the State has decided to initiate NRDA activities at the Site.

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