Assessment of the Mineral Potential of Public Lands Located within a Proposed Solar Energy Zone in New Mexico

July 2012

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The following is a list of acronyms, abbreviations, and units of measure used in this document. Some acronyms used only in tables may be defined only in those tables.

GENERAL ACRONYMS AND ABBREVIATIONS

BLM	Bureau of Land Management
CBO	Congressional Budget Office
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EERE	[Office of] Energy Efficiency and Renewable Energy [DOE]
FLPMA	Federal Land Policy and Management Act of 1976
FR	*Federal Register*
GIS	geographic information system
I	Interstate
IBLA	Interior Board of Land Appeals
INEEL	Idaho National Engineering and Environmental Laboratory
LR2000	Land and Mineral Legacy Rehost 2000 System
MRDS	Mineral Resource Data System
NMBGMR	New Mexico Bureau of Geology and Mineral Resources
NMEMNRD	New Mexico Energy, Minerals and Natural Resources Department
NMOCD	New Mexico Oil Conservation Division
PEIS	programmatic environmental impact statement
P.L.	Public Law
P.M.	principal meridian
ROW	right-of-way
SEZ	solar energy zone
U.S.	United States
USC	*United States Code*
USFS	U.S. Forest Service

USGS	U.S. Geological Survey

UNITS OF MEASURE

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
ft	foot (feet)
km	kilometer(s)
km^2	square kilometer(s)
m	meter(s)
mi	mile(s)

ASSESSMENT OF THE MINERAL POTENTIAL OF PUBLIC LANDS LOCATED WITHIN A PROPOSED SOLAR ENERGY ZONE IN NEW MEXICO

LANDS INVOLVED

Afton Solar Energy Zone
Covering 29,964 acres of public land in Doña Ana County, New Mexico

T24S, R2W, sections 23 to 26, and 35
T24S, R1W, sections 19, 28 to 35
T25S, R2W, section 1
T25S, R1W, sections 1, 3 to 6, 8 to 15
T25S, R1E, sections 7, 8, 14, 15, 17 to 23, 25 to 30, and 33 to 35
New Mexico P.M.

Prepared by:

Terri L. Patton

Terri L. Patton, Geologist

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ASSESSMENT OF THE MINERAL POTENTIAL OF PUBLIC LANDS LOCATED WITHIN A PROPOSED SOLAR ENERGY ZONE IN NEW MEXICO

SUMMARY

The report that follows presents an assessment of mineral resource potential of public lands located within a proposed solar energy zone (SEZ) in south–central New Mexico, on behalf of the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM). The assessment was conducted in consultation with three BLM mineral specialists: Mr. Matt Shumaker, Chief Mineral Examiner (Division of Solid Minerals); Mr. Jason Powell, Geologist (Division of Solid Minerals); and Mr. Michael Smith, Geologist (Las Cruces District Office). Mr. Jeff Holdren, Senior Realty Specialist (Division of Lands, Realty, and Cadastral Survey) prepared the legal description for the SEZ.

The subject lands are located within the Afton SEZ in Doña Ana County. There are no documented occurrences of locatable mineral deposits within the site. Most of the locatable minerals in the region occur in the Organ Mountains, bordering the east side of Mesilla Valley, where the major deposits include copper, lead, zinc, silver, and gold. These deposits are associated with the many intrusions making up the Organ batholith. Alluvial and basin-fill sediments below the SEZ are estimated to be about 3,000 ft (915 m) thick. The occurrence of mineralized zones below the site is unconfirmed, but based on geologic studies to date, they are likely to be very deep (below basin sediments) if present. Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).[1]

The Afton SEZ lies within the Aden District, an industrial mining area that produces volcanic materials (mainly scoria). The SEZ is an area with a high potential for occurrence of sand and gravel, pumice, and scoria (level of certainty D). Although there are currently no free use permits or mineral materials contracts within the SEZ, past mining of sand and gravel, pumice, and scoria within the site indicates that future extraction of such deposits is viable.

There are no active oil and gas leases within the Afton SEZ. The southeastern portion of the site was leased in the past, but these leases were closed in the mid- to late-1980s. Although several test wells were drilled in Doña Ana County in the 1950s, there has been no oil or natural gas production in the county. Relative to more favorable areas for oil and gas accumulation and production in the state (concentrated in the southeastern counties of New Mexico), the SEZ is an

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1 Definitions of mineral potential are from the mineral potential classification system outlined in *BLM Manual 3031* (BLM 1985). Mineral potential ratings of low, moderate, or high are assigned where the geologic environment and inferred geologic processes indicate low, moderate, or high potential for accumulation of mineral resources. Levels of certainty are defined as follows: A = available data are *insufficient* to support or refute the occurrence of mineral resources; B = available data provide *indirect* evidence to support or refute the occurrence of mineral resources; C = available data provide *direct but quantitatively minimal* evidence to support or refute the occurrence of mineral resources; and D = available data provide *abundant direct and indirect* evidence to support or refute the occurrence of mineral resources.

area with low potential for oil and gas development (level of certainty B). Potential reservoir rocks in the Mesilla-Mimbres Basins region are still under study.

The SEZ is located in the Las Cruces District, an area of high geothermal potential; however, there are no active or historical geothermal leases and no nominated lands for geothermal sale within the site. Most of the geothermal resources in the region are concentrated on East Mesa near Tortugas Mountain, about 15 mi (24 km) to the northeast of the site and trending southward along I-10 and I-25 nearly to the New Mexico–Texas state line. The geothermal system in this region, called the Las Cruces East Mesa system, is one of the largest “convective” low-temperature (i.e., <90°C [<194°F]) geothermal systems in the United States, with reservoir temperatures ranging from 40 to 70°C (104 to 158°F). It sits above a buried horst block of mid-Tertiary volcanics and Paleozoic carbonates. In the vicinity of the SEZ, however, reservoir temperatures are typically less than 40°C (104°F). The potential for development of geothermal energy within the SEZ is low (level of certainty B).

1 INTRODUCTION

1.1 PURPOSE OF REPORT

The purpose of this report is to assess the mineral resource potential of 29,964 acres (121 km^2) of public lands within the Afton SEZ in south–central New Mexico, which the Secretary of the Interior may decide to withdraw from potentially conflicting uses through the issuance of a Public Land Order. If the order is approved, the public lands within the SEZ would be withdrawn, subject to valid existing rights, from settlement, sale, location, or entry under the general land laws, including the mining laws, as follows:

- New mining claims could not be filed on the withdrawn lands; however, valid mining claims filed prior to the date the lands were segregated (i.e., withdrawal application notice was published in the *Federal Register*) would take precedence over future solar energy development right-of-way (ROW) application filings.

- Lands could not be sold, exchanged, or otherwise disposed of during the term of the withdrawal.

- Withdrawn lands would remain open to mineral leasing, geothermal leasing, and mineral material laws; the BLM could elect to lease the oil, gas, coal, or geothermal steam resources, or to sell common-variety mineral materials such as sand and gravel, if the authorized officer determined there would be no unacceptable impacts on future solar energy development.

- Withdrawn lands would remain open to ROW authorizations and land leases or permits authorized under Section 302 of the Federal Land Policy and Management Act of 1976 (FLPMA).

The public lands within the Afton SEZ are currently segregated under an Interim Temporary Final Rule, which was published on April 26, 2011, and is in effect until June 30, 2013 (Vol. 76, pp. 23198–23205 of the *Federal Register* [76 FR 23198–23205]).

1.2 LEGAL DESCRIPTION OF THE SUBJECT LANDS

The Afton SEZ is the only site in New Mexico proposed as part of the Solar Energy Program. It is located in the Las Cruces District in Doña Ana County. Two other proposed SEZs, Mason Draw (Doña Ana County) and Red Sands (Otero County), were eliminated from further consideration on the basis of public comments received on the Draft Solar Programmatic Environmental Impact Statement (PEIS) (BLM and DOE 2010). The Supplement to the Draft PEIS provides the rationale for eliminating the SEZs (BLM and DOE 2011).

The Afton SEZ lies within Township 24 south, Range 2 west (T24S, R2W), sections 23 to 26, and 35; T24S, R1W, sections 19 and 28 to 35; T25S, R2W, section 1; T25S, R1W, sections 1, 3 to 6, and 8 to 15; and T25S, R1E, sections 7, 8, 14, 15, 17 to 23, 25 to 30, and 33 to 35 (New Mexico Principal Meridian). The location of the SEZ is shown in Figure 1.

1.3 METHODOLOGY AND RESOURCES

The assessment presented in this report focuses on locatable (including those classified as strategic and critical), saleable, and leasable mineral resources within the Afton SEZ in New Mexico. The conclusions concerning mineral occurrence and development potential (and levels of certainty) follow the methodology outlined in *BLM Manual 3031* (BLM 1985) and are based on a review of topographic maps, geologic maps, mineral resource maps and reports, the scientific literature on the geology and mineral resources of New Mexico, and consultation with BLM mineral specialists. No mapping or field sampling was conducted as part of this assessment.

Digital data for the geologic map in Figure 2 were obtained from the U.S. Geological Survey (USGS) (Stoeser et al. 2007). The dataset was digitized from previously published geologic maps ranging in scale from 1:100,000 to 1:1,000,000. Detailed map unit descriptions for this map are based on the published state geologic map by Scholle (2003). The large-scale, folded map (Map 1) provided in the back of this report shows the public land survey system grid (township and range) and should be consulted to locate mines and other features discussed in the text. In addition, the Solar PEIS Web site (http://solareis.anl.gov/sez/index.cfm) features mapped photographs of the SEZ.

The BLM's Legacy Rehost System (LR2000; BLM 2012) was queried on July 11, 2012, for information on active and historical (unpatented) mining claims and various leases and permits, including oil and gas leases, geothermal leases and land nominations, free use permits, and mineral materials contracts, issued on public lands within and around the proposed SEZ. Another key BLM resource consulted was the Las Cruces District Office Mimbres Resource Area Resource Management Plan (BLM 2008).

Mines and mineral prospects and occurrences and their descriptions are those reported in the U.S. Geological Survey (USGS) Mineral Resource Data System (MRDS; USGS 2011a; Lipin 2000) and supplemented with information provided by Mr. Mike Smith, a mineral specialist from the Las Cruces District, the BLM district in which the proposed SEZ is located. The MRDS is a large database containing historical records of the USGS and the U.S. Bureau of Mines (which is now part of the USGS). These records are of variable quality and currency, so it is possible that some information will be found to be out of date (the revision and refinement of the database is an ongoing effort at the USGS). The mining activity map in Figure 3 was prepared from the MRDS and is intended to provide a general picture of the location and nature of mining activity in the vicinity of the SEZ. Refinements with regard to the status of particular mines are included in the text as warranted based on conversations with Mr. Smith.

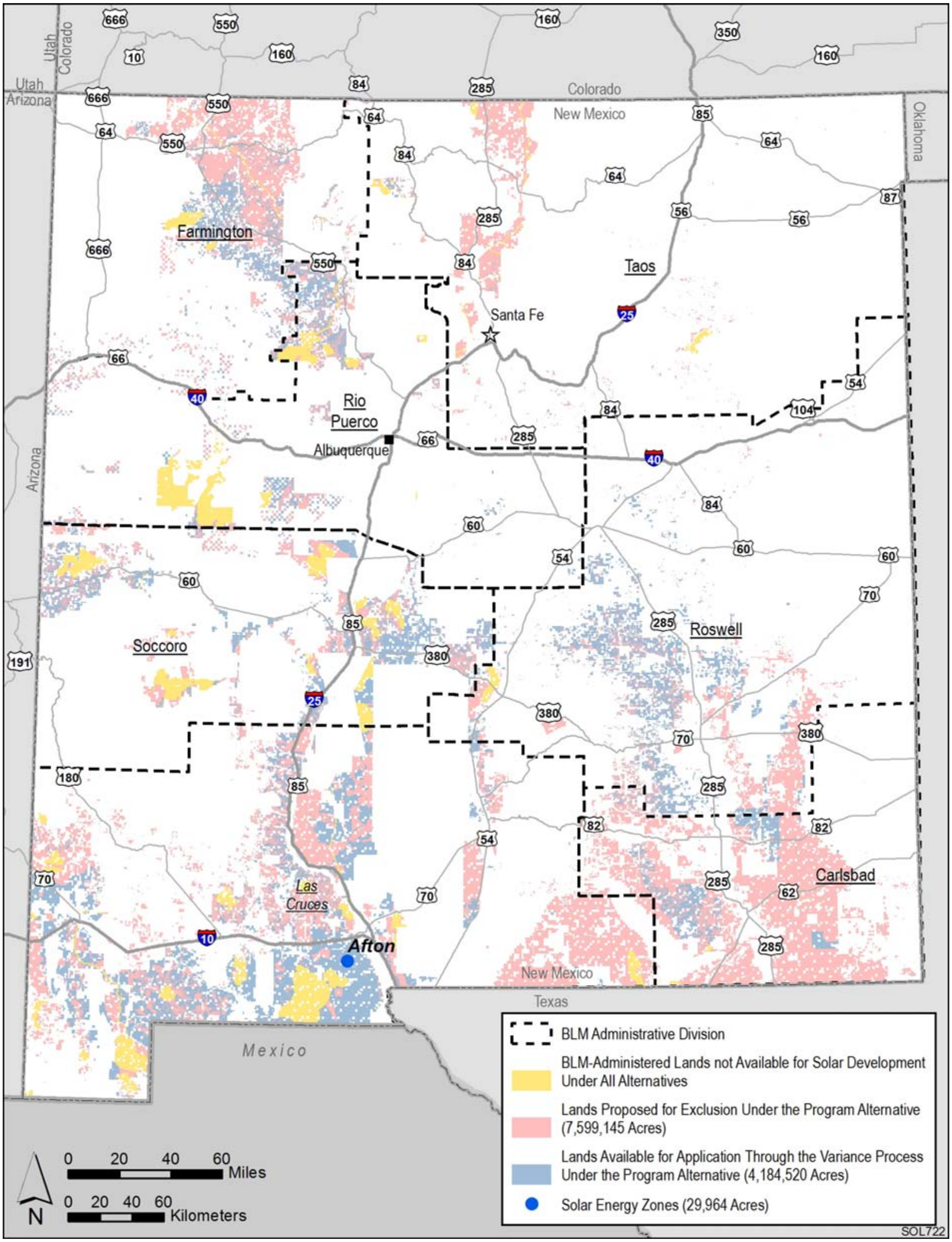

FIGURE 1 BLM-Administered Lands in New Mexico Available for Application for Solar Energy Right-of-Way Authorization (the Afton SEZ is represented by the blue dot)

Geographic information system (GIS) data for New Mexico's mining districts, based on McLemore et al. (2005), were obtained from the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) for the mining activity maps. Information on pending and approved mining permits and the locations of active mines, mills, and quarries in Doña Ana County is from the permits page and map page of the New Mexico Energy, Minerals and Natural Resources Department (NMEMNRD) Web site (http://www.emnrd.state.nm.us/MMD/index.htm).

1.4 LOCATABLE MINERALS

Under United States (U.S.) mining laws, minerals fall into three categories: locatable, leasable, and saleable. Because these categories were created by acts of Congress, they do not fall into simple economic or mineralogical divisions. Creating an exact and thorough list of locatable minerals (e.g., those subject to appropriation by locating mining claims) is therefore difficult. Metallic minerals (e.g., gold, silver, copper, mercury, aluminum, antimony, lithium, molybdenum, tungsten, uranium, vanadium, and rare earths) are considered to be locatable. Numerous uncommon varieties of nonmetallic minerals may also be locatable, depending on their chemical content, quality, uses, and characteristics, as well as on certain associated economic and legal matters. These nonmetallic minerals could include barite, calcite, specialty clays, bentonite, diatomite, feldspar, some gemstones (e.g., opals and diamonds), gypsum, chemical-grade limestone, perlite, chemical-grade silica sand, specific types of stone, talc, zeolites, and specific and uncommon types of dolomite. The determination of the actual locatability of uncommon varieties of nonmetallic minerals and the validity of mining claims for them is complex and relies on Public Law (P.L.) 84-167 (*United States Code*, Title 30, Section 601 et seq. [30 USC 601 et seq.]) and applicable case law (e.g., *U.S. vs. Kenneth McClarty*, 17 Interior Board of Land Appeals [IBLA] 20, 1974 [81 Interior Department (I.D.) 472]) (Shumaker 2011).

More than 400 exploration and mining permits were filed with the State of New Mexico in 2008. That year, nonfuel raw mineral production was up by more than 2% over that in 2007. The top nonfuel minerals (by value of production) were copper, potash, molybdenum concentrates, construction sand and gravel, and portland cement. Copper is the leading nonfuel mineral produced in New Mexico, accounting for 45% of the state's total nonfuel mineral production value. Significant increases in the production values of potash, silver, gold, crude gypsum, crude perlite, salt, industrial sand and gravel, masonry cement, and molybdenum concentrates occurred in 2008. New Mexico continued to be the lead U.S. producer of potash, crude perlite, and zeolites and remained third in the production of copper (USGS 2011b).

1.5 STRATEGIC AND CRITICAL MINERALS

Table 1 lists the nonfuel strategic and critical nonfuel minerals that are imported by the United States for its National Defense Stockpile, as authorized by the Strategic and Critical Materials Stock Piling Act (50 USC 98 et seq.). Several of the minerals produced in New Mexico are classified as strategic and critical minerals; these include bismuth, copper, fluorspar, manganese, tungsten, vanadium, and zinc.

TABLE 1 Strategic and Critical Nonfuel Minerals

Antimony	Copper	Platinum group
Asbestos	Diamonds (industrial)	Quartz crystals
Bauxite and alumina	Fluorspar	Rutile (titanium)
Beryllium	Graphite	Silicon
Bismuth	Iodine	Tantalum
Cadmium	Manganese	Thorium
Chromium	Mercury	Tin
Cobalt	Mica sheet	Tungsten
Columbian	Nickel	Vanadium
		Zinc

Source: CBO (1983).

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2 AFTON SEZ

2.1 SUMMARY AND CONCLUSIONS

This chapter assesses the mineral resource potential of 29,964 acres (121 km^2) of public lands within an area known as the Afton SEZ, located in Doña Ana County in south–central New Mexico, about 5 mi (8 km) southwest of Las Cruces, New Mexico.

There are no documented occurrences of locatable mineral deposits within the Afton SEZ. Most of the locatable minerals in the region occur in the Organ Mountains, bordering the east side of Mesilla Valley, where the major deposits include copper, lead, zinc, silver, and gold. These deposits are associated with the many intrusions making up the Organ batholith. Alluvial and basin-fill sediments below the SEZ are estimated to be about 3,000 ft (915 m) thick. The occurrence of mineralized zones below the site is unconfirmed, but based on geologic studies to date, they are likely to be very deep (below basin sediments) if present. Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

The Afton SEZ lies within the Aden District, an industrial mining area that produces volcanic materials (mainly scoria). The SEZ is an area with a high potential for occurrence of sand and gravel, pumice, and scoria (level of certainty D). Although there are currently no free use permits or mineral materials contracts within the SEZ, past mining of sand and gravel, pumice, and scoria within the site indicate that future extraction of such deposits is viable.

There are no active oil and gas leases within the Afton SEZ. The southeastern portion of the site was leased in the past, but these leases were closed in the mid- to late-1980s. Although several test wells were drilled in Doña Ana County in the 1950s, there has been no oil or natural gas production in the county. Relative to more favorable areas for oil and gas accumulation and production in the state (concentrated in the southeastern counties of New Mexico), the SEZ is an area with low potential for oil and gas development (level of certainty B). Potential reservoir rocks in the Mesilla-Mimbres Basins region are still under study.

The SEZ is located in the Las Cruces District, an area of high geothermal potential; however, there are no active or historical geothermal leases and no nominated lands for geothermal sale within the site. Most of the geothermal resources in the region are concentrated on East Mesa near Tortugas Mountain, about 15 mi (24 km) to the northeast of the site and trending southward along I-10 and I-25 nearly to the New Mexico–Texas state line. The geothermal system in this region, called the Las Cruces East Mesa system, is one of the largest "convective" low-temperature (i.e., <90°C [<194°F]) geothermal systems in the United States, with reservoir temperatures ranging from 40 to 70°C (104 to 158°F). It sits above a buried horst block of mid-Tertiary volcanics and Paleozoic carbonates. In the vicinity of the SEZ, however, reservoir temperatures are typically less than 40°C (104°F). The potential for development of geothermal energy within the SEZ is low (level of certainty B).

2.2 LANDS INVOLVED

The Afton SEZ is located on BLM lands in the Mimbres Resource Area (Las Cruces District), in Doña Ana County (BLM 1993, 2008). The site lies within Township 24 south, Range 2 west (T24S, R2W), sections 23 to 26 and 35; T24S, R1W, sections 19 and 28 to 35; T25S, R2W, section 1; T25S, R1W, sections 1, 3 to 6, and 8 to 15; and T25S, R1E, sections 7, 8, 14, 15, 17 to 23, 25 to 30, and 33 to 35 (New Mexico Principal Meridian). Within this area, 742 acres (3 km^2) of floodplain and intermittent and dry lakes have been designated as non-development areas (BLM and DOE 2011). The SEZ and the non-development areas within it are shown on the location map in the back of this report (Map 1).

2.3 LAND STATUS

According to the LR2000, accessed on July 11, 2012, there are no active or historical locatable mining claims within the Afton SEZ (BLM 2012). The lands within the SEZ were first segregated from locatable mineral entry in June 2009, pending the outcome of the Draft Solar Energy PEIS (BLM and DOE 2010). They are currently segregated under an Interim Temporary Final Rule, which is in effect until June 30, 2013 (76 FR 23198–23205).

There are currently no free use permits or mineral materials contracts within the SEZ (BLM 2012). A small operation producing pumice and scoria (volcanic cinder) on 20 acres (0.081 km^2) at the east end of the site just south of Little Black Mountain (in section 25 of T25S, R1E) was closed in 1995; a free use permit for sand and gravel (in section 21 of T25S, R1E) was closed in 2002. The Little Black Mountain pit, located immediately east of the SEZ and south of Afton Road (in section 24 of T25S, R1E), also produced scoria, but it is currently inactive (Smith 2012a). The site remains open for the disposal of saleable mineral materials.

There are no active oil and gas leases within the SEZ; however, the site was leased for oil and gas in the past (13 oil and gas leases covered the southeastern portion of the site but were closed in the mid- to late-1980s). There are no active or historical geothermal leases and no nominated lands for geothermal sale within the SEZ. The site remains open for discretionary leasing for oil and gas, geothermal, and other leasable minerals.

2.4 GEOLOGIC SETTING

The Afton SEZ is located on the West Mesa of the Mesilla Basin, an alluvium-filled structural basin within the Basin and Range physiographic province in south–central New Mexico. West Mesa is bordered on the north by the Rough and Ready Hills and the Robledo Mountains; on the west by the Sleeping Lady Hills, Aden Hills, and the West Potrillo Mountains; and on the east by the Mesilla Valley. The United States–Mexico border marks its southern boundary (Myers and Orr 1985).

The Mesilla Basin is an axial basin of the Rio Grande rift, a north-trending tectonic feature that extends from south–central Colorado to northern Mexico, crossing (and bisecting) the length of New Mexico. Basins in the rift zone generally follow the course of the Rio Grande and are bounded by normal faults that occur along the rift zone margins. The Mesilla Basin extends about 60 mi (100 km) from the upper Mesilla Valley between the Robledo and Doña Ana Mountains to the United States–Mexico border just west of El Paso, Texas. It ranges in width from about 5 mi (8 km) at its northern end (north of Las Cruces) to 25 mi (40 km) in its central part (halfway between Las Cruces and the international border) (Hawley and Lozinsky 1992; Chapin 1988).

West Mesa is a broad plain with low topographic relief covering an area of about 480 acres (1,940 km^2). It lies immediately west of the broad Mesilla Valley of the Rio Grande, the primary surface water feature in the Mesilla Basin. The mesa surface sits about 300 to 350 ft (90 to 110 m) above the river. The mesa (also referred to as “La Mesa”) is an extensive remnant of the basin floor surface that existed before it was incised by the Rio Grande. The eastern edge of the mesa is marked by a steep slope heavily dissected by arroyos (ephemeral streams or gullies) that are tributaries to the Rio Grande (Hawley and Lozinsky 1992; Myers and Orr 1985). The geology of the Mesilla Basin near the Afton SEZ is shown in Figure 2.

2.5 PHYSICAL FEATURES AND ACCESS

The Afton SEZ is located a few miles west of the Rio Grande. Its terrain is fairly flat, with a gentle slope to the southeast toward the river. A northeast-trending ridge, with a maximum relief of about 250 ft (76 m), cuts across the northwest end of the site. Elevations across the SEZ range from about 4,370 ft (1,330 m) at its northwest end to about 4,150 ft (1,260 m) in the low-lying area at the central part of the site. The area immediately east of the SEZ has a fairly steep grade and is cut by gullies draining to the Rio Grande.

The SEZ is accessible via several dirt/gravel roads and four county roads. The Las Cruces Municipal Airport is about 6 mi (9.6 km) to the north.

2.6 SITE GEOLOGY

The geology of the Afton SEZ is described based on the logs of test wells drilled in the area (Hawley and Lozinsky 1992). An example log from a test boring (24S.01E.08.123) drilled about 5 mi (8 km) north of the SEZ is shown in Table 2; the well’s location is shown in Figure 2. The thicknesses of the Santa Fe Group members shown in Table 2 were inferred from a geologic cross section prepared from a transect across the site (from Hawley and Lozinsky 1992).

The SEZ is underlain by basin fill consisting of late Tertiary to Quaternary sediments of the Santa Fe Group, which are up to 3,000-ft (915-m) thick below the site, thinning to the north and west. Santa Fe Group sediments are classified mainly on the basis of lithology and depositional environment rather than on fossils or time boundaries. The lower and middle units of the Santa Fe Group were deposited during the development of the Rio Grande rift (Miocene to Pliocene), when the basin was an internally drained (bolson) environment; they are predominantly made up of eolian sands and fine-grained basin floor and playa lake sediments

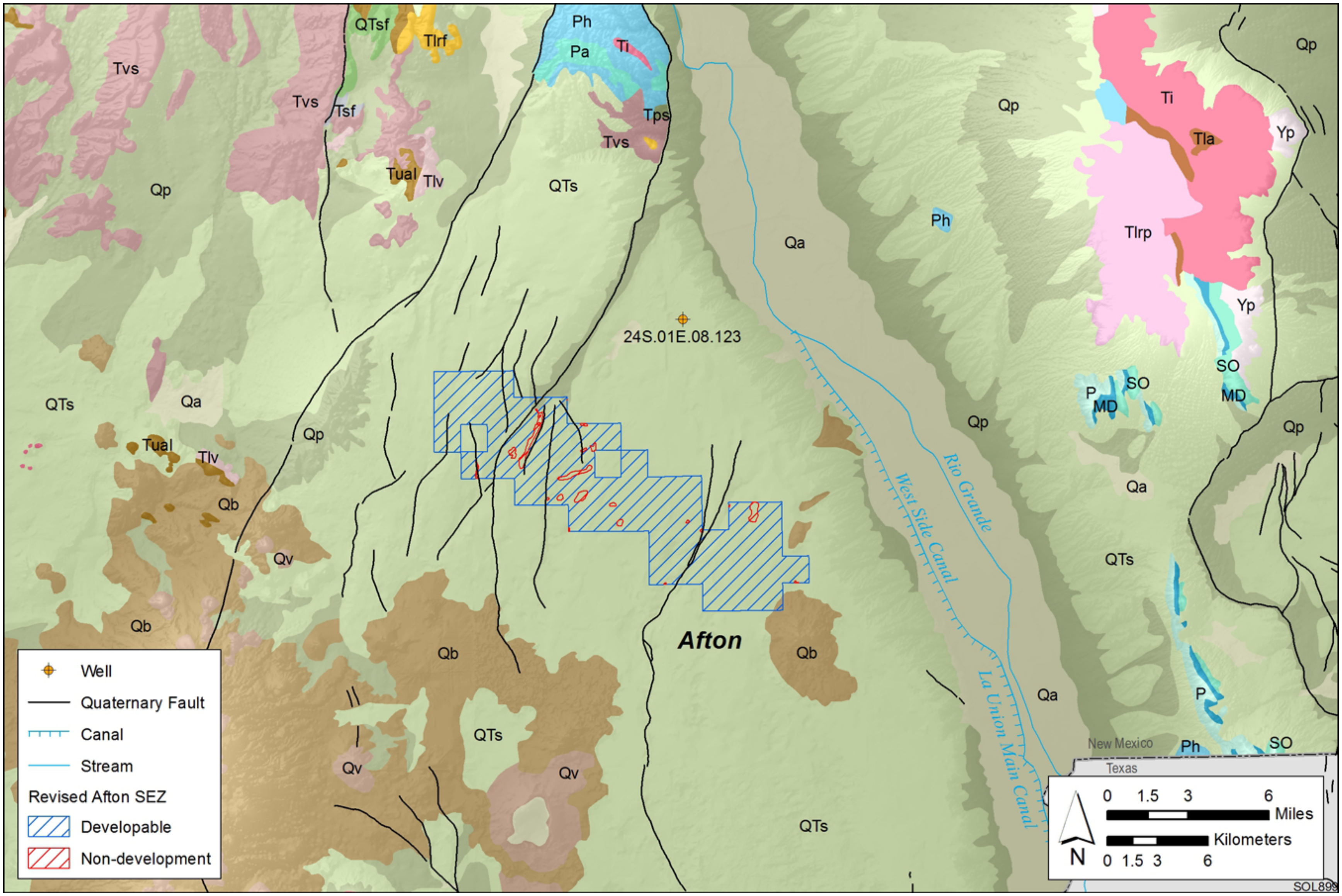

FIGURE 2 Geologic Map of West Mesa in the Vicinity of the Afton SEZ (Sources: Stoeser et al. 2007; Scholle 2003)

Cenozoic (Quaternary, Tertiary)

Qa	Alluvium
Qp	Piedmont alluvial deposits
Qb	Volcanic; basaltic and andesitic lavas, vent deposits
Qv	Volcanic; basaltic lavas and tephra
QTs	Basin fill; Upper Santa Fe Group
QTsf	Basin fill; Middle Santa Fe Group
Tsf	Basin fill; Lower Santa Fe Group
Tual	Volcanic; basaltic andesites and andesites
Tvs	Volcaniclastic sedimentary rocks
Tlrf	Volcanic; rhyolitic lavas and local tuffs
Tlrp	Volcanic; rhyolitic to dacitic pyroclastics, lavas, ash-flow tuffs
Tla	Volcanic; andesitic to dacitic lavas, pyroclastic flow breccias
Tlv	Volcanic; intermediate lavas, volcaniclastic sediments
Ti	Intrusives; intermediate to felsic
Tps	Sedimentary units (Paleogene)

Paleozoic

P	Sedimentary rocks; undivided
Pa	Abo Formation (red beds, limestone)
Ph	Hueco Formation (limestone)
MD	Sedimentary rocks; undivided (Devonian to Mississippian)
SO	Sedimentary rocks; undivided (Ordovician to Silurian)

Precambrian

Yp	Granitic plutonic rocks (Middle Proterozoic)

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FIGURE 2 (Cont.)

TABLE 2 Lithologic Log for Test Well 24S.01E.08.123

Lithology	Stratigraphic Unit	Thickness (ft)	Depth (ft)
Sand, fine-grained	Upper Santa Fe	2	0–2
Caliche, white, variable hardness	Group	14	2–16
Sand with clay layers		4	16–20
Gravel with sand		3	20–23
Fine-grained sand with clay lenses		81	23–104
Clay		19	104–123
Sand, fine-grained, with clay lenses		29	123–152
Sand, medium- to fine-grained, with clay lenses		57	152–209
No samples		64	209–273
Sand, fine-grained, with occasional thin clay layers (<10 ft)		263	273–536
Clay lenses		14	536–550
Sand, fine-grained, with occasional thin clay layers (<10 ft)		86	550–636
Clay with many very fine to medium-grained sand lenses		72	636–708
Sand, very fine to medium-grained, with clay lenses	Middle	548	708–1,256
Clay, sandy, silty	Santa Fe Group	148	1,256–1,404
Sand, very fine to medium-grained, with some clay; thin gravel lenses in clay 1,570 to 1,600 ft		172	1,404–1,576
Clay with many thin sand or sand and gravel lenses		180	1,576–1,756
Sand, very fine to fine-grained, with many clay layers and lenses; 50% of unit is clay		524	1,756–2,280
Clay with thin to thick silty sand layers and lenses and some small gravel; about 50% of the unit is green to black rock material from 2,370 to 2,464 ft	Lower Santa Fe Group	184	2,280-–2,464

intertongued with alluvial fan deposits. The lower Santa Fe Group overlies middle Tertiary (Oligocene to Miocene) volcanic and volcaniclastic sedimentary rocks. The lower and middle units of the Santa Fe Group are about 700- and 1,300-ft (215- and 396-m) thick, respectively, below the SEZ.

Above the lower and middle units are the fluvial-deltaic sands of the upper Santa Fe Group (Pliocene to Pleistocene). These sediments were deposited on a broad plain by the braided channels of the ancestral Rio Grande, which spread across the basin floor and terminated in a large playa lake in north–central Mexico (Bolson de los Muertos). The main component of the upper Santa Fe Group is the Camp Rice Formation; it is well preserved throughout most of the Mesilla Basin, ranging in thickness from about 300 to 700 ft (90 to 215 m). The upper Santa Fe Group is about 700-ft (215-m) thick beneath the Afton SEZ (Frenzel et al. 1992; Hawley and Lozinsky 1992; Myers and Orr 1985).

Exposed sediments on West Mesa consist mainly of coarse- to medium-grained basin-fill deposits of the Upper Santa Fe Group. Three distinct facies are present in the upper Santa Fe Group in the vicinity of the SEZ:

1. Sandy and pebbly gravel, with thin discontinuous beds and lenses of sandstone, silty sand, and silty clay; usually nonindurated but with local zones that are cemented with calcite and other minerals, including silicate clays, iron-manganese oxides, gypsum, silica, and zeolites.

2. Sand, with discontinuous beds and lenses of pebbly sand, silty sand, sandstone, silty clay, and mudstone; nonindurated.

3. Interbedded sand, silty sand, silty clay and sandstone, with minor lenses of pebbly sand, conglomeritic sandstone; usually nonindurated.

Post-Santa Fe Group alluvial fan piedmont deposits of silt, sand, and gravel occur mainly along mountain fronts and to the northeast of the SEZ where the mesa surface has been cut by the Rio Grande. These sediments also occur along the northeast-trending ridge that cuts across the northwest corner of the site. Tertiary volcanic rocks of basaltic to andesitic composition cap the East and West Potrillo Mountains to the southwest of the SEZ. The oldest rocks in the region are the Middle Proterozoic granitic rocks exposed in parts of the Organ Mountains to the northeast of the Rio Grande. These rocks have been intruded by Tertiary monzonitic and granitic plutons and dikes. Paleozoic sedimentary rocks (mainly carbonates) crop out in the Robledo Mountains to the north and the Organ and Franklin Mountains to the east (Hawley and Lozinsky 1992; Scholle 2003).

2.7 MINERAL HISTORY

The only documented mining within the Afton SEZ has been for industrial minerals (scoria, and sand and gravel); however, there has not been any mining at the site since 2002. Scoria has also been produced from the two Santo Tomas pits to the northeast of the site and from Little Black Mountain to the east. Most of the mining activity in the region has been limited to the small-scale mining of industrial minerals (scoria, sand and gravel, brick clay, and stone) on West Mesa and along the Rio Grande valley and the mining of locatable minerals in the various mining districts to the north and northeast (Figure 3; see also Map 1).

Active mines in Doña Ana County produce industrial minerals such as aggregate, calcite, scoria, clay, shale, and gypsum. There are several aggregate and limestone mines on the mesa and along the river valley (NMEMNRD 2012a; USGS 2011a; Smith 2012b).

As of July 11, 2012, there were no pending or approved locatable mineral exploration or mine applications posted for Doña Ana County on the NMEMNRD's permit applications Web page (NMEMNRD 2012b). The only approved mining application in 2011 was for a small gypsum mine (Alley Gypsum) in the northern part of the county, but the mine was closed in March 2011 (Smith 2012b). The USGS *2008 Minerals Yearbook* reports that several companies explored for gold and silver in Doña Ana County in 2007 (USGS 2011b).

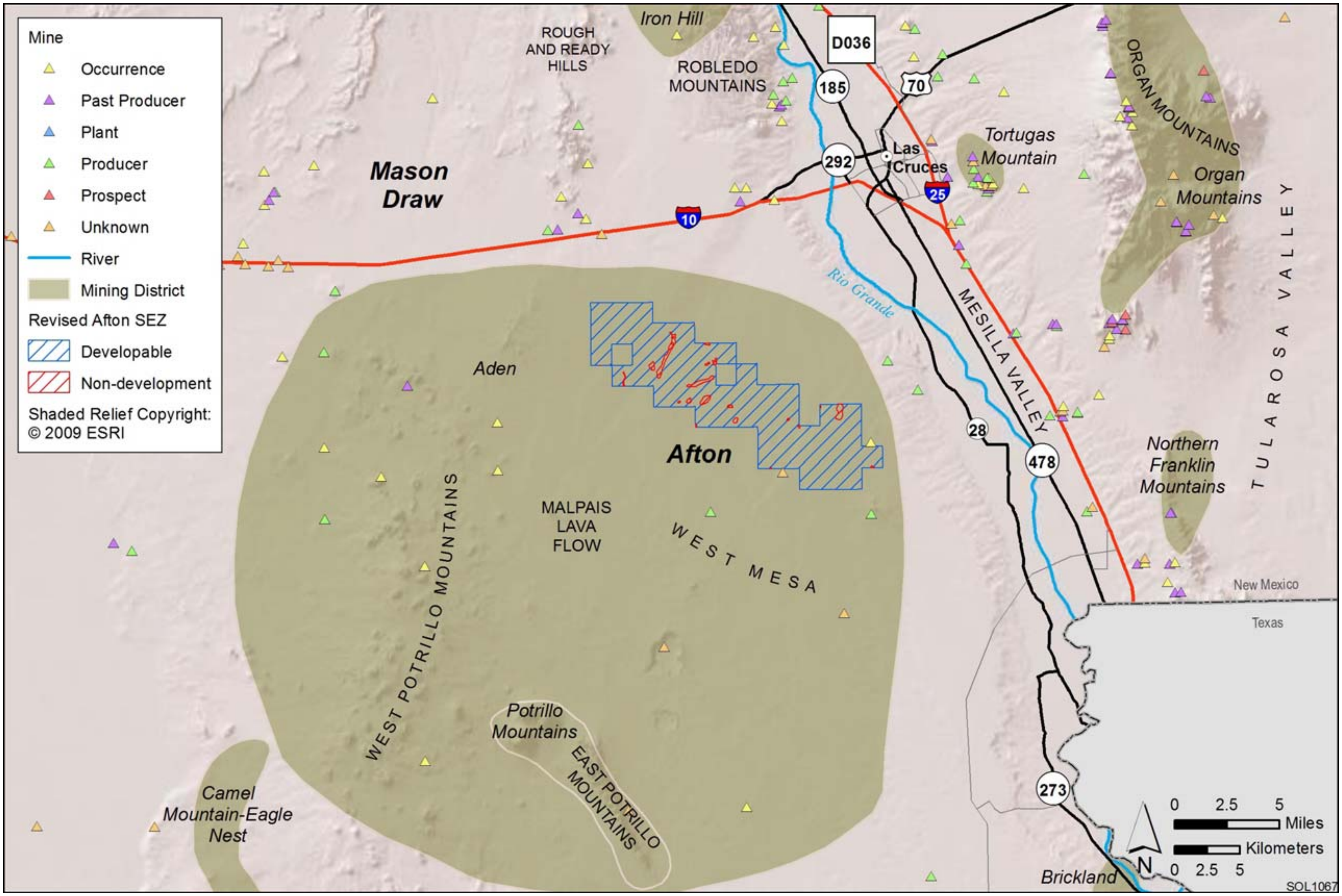

FIGURE 3 Map Showing Mining Districts, Mines, and Mineral Prospects near the Afton SEZ (Sources: USGS 2011a; McLemore et al. 2005)

2.7.1 Locatable Minerals

There are no documented occurrences of locatable mineral deposits or prospects within the Afton SEZ (BLM 2012). Most of the locatable minerals in the region occur in the Organ Mountains, bordering the east side of Mesilla Valley, where the major deposits include copper, lead, zinc, silver, and gold. Other minerals include barite, fluorite, uranium (co-occurring with fluorite veins; McLemore 1983), vanadium, and bismuth. These deposits are associated with the many intrusions making up the Organ batholith, including the granite of Granite Peak, the Sugarloaf Peak quartz monzonite, the Organ Needle quartz syenite, and numerous rhyolite dikes (McLemore et al. 1996; Dunham 1935). Comparable units, if present below the Afton SEZ, are buried by basin-fill sediments that are up to 3,000-ft (915-m) thick.

Mines and prospects in the vicinity of the SEZ are shown in Figure 3. A detailed map (Map 1) of the SEZ and surrounding region is provided in the back of this report. The nearest occurrences of locatable minerals are the Lauer Claims and the Manganese No. 1 Claim; these potential manganese deposits are located in unconsolidated sediments across I-10 about 8 mi (13 km) to the north of the SEZ. Material sampled at these sites contained less than 10% manganese, and the deposits were never developed (USGS 2011a). Two placer claims (Black Bear #1 and Black Mountain #6) are located on BLM land a few miles to the south of the SEZ in section 12 of T26S, R1E (BLM 2012; Smith 2012b); but they are not represented in the USGS MRDS and do not appear in Figure 3.

There are five metallic mining districts in the vicinity of the Afton SEZ; all within Doña Ana County (the Camel-Mountain-Eagle Nest District, also shown in Map 1, is located in Luna County; it is currently inactive). Some of the minerals produced in these districts are not classified as locatable minerals. The mining districts and their mineral occurrences, based on McLemore et al. (2005), are shown in Figure 3 and are as follows:

- Potrillo Mountains: copper, gold, silver, lead, and travertine; to the south–southwest;
- Camel Mountain-Eagle Nest: gold, silver, lead, zinc, fluorite, and manganese; to the southwest;
- Iron Hill: iron and travertine; to the north;
- Tortugas Mountain: fluorite, manganese, and barite; to the northeast; and
- Organ Mountains: copper, lead, zinc, silver, gold, uranium, vanadium, fluorite, barite, bismuth, and brick clay; to the northeast.

The Potrillo Mountains District encompasses the Potrillo Mountains, which lie to the south–southwest of the SEZ. Mining began in the district in the 1880s and produced gold, copper, silver, and lead. During exploratory drilling in the 1980s, mineralized zones with high silver values were found; however, there are currently no active mines in the district (McLemore et al. 1996; USGS 2011a).

Mining in the Iron Hill District, located in the southwestern Robledo Mountains, began in the early 1930s. Mineral deposits in the district consist predominantly of hematite, goethite, and limonite, with local concentrations of manganese oxides, gypsum, calcite, quartz, and ochre. These deposits are hosted by limestones of the Hueco Formation (Permian) and occur as lenticular replacements, breccia cement, and cavity fillings. Banded travertine, used as a decorative stone, has also been quarried in the district (McLemore et al. 1996). The only active mine in the district is a limestone quarry (Rainbow Mine) (USGS 2011a).

The Tortugas Mountain District, discovered in 1900, has produced barite, fluorite, and manganese from mineralized faults and fracture zones within altered (silicified and dolomitized) Permian limestones; these occur as fluorite-calcite veins. Small travertine deposits also occur in the northern part of the mountain (McLemore et al. 1996). Active mines in the district produce limestone (Hueco Formation) and sand and gravel (Rio Grande Rock Pit and Perez Pit; USGS 2011a).

Mineral deposits were first discovered in the Organ Mountains District in the 1830s. Since then the district has produced copper, lead, zinc, silver, and gold, as well as barite, fluorite, uranium, vanadium, and bismuth. Mineral deposits are associated with an intrusive center and distributed in concentric zones, beginning with a copper-molybdenum core, surrounded by zones of zinc-lead, lead-zinc, gold-silver, and an outer zone of fluorite-barite. Exploration drilling and lithology studies in the 1980s indicate that at least three porphyry copper-molybdenum systems occur in the district. The potential for copper breccia, skarn, carbonate-hosted lead-zinc replacement, epithermal/mesothermal veins, and fluorite deposits in the Organ Mountains is moderate (McLemore et al. 1996; Ludington et al. 1988; Dunham 1935). The Torpedo Mines may still produce copper, silver, lead, and zinc in the district (USGS 2011a).

The Northern Franklin Mountains District, discovered in 1914, covers the northern portion of the Franklin Mountains that extends into New Mexico. The area has produced small amounts of lead (galena) and silver from a Rio Grande Rift deposit and several hundred short tons of jarosite (a hydrous sulfate of potassium and iron) and gypsum. Mineral deposits occur in dolomitic limestones of the Fusselman Formation as veins and replacements of barite, fluorite, lead, calcite, iron oxides, and quartz. There are currently no active mines in the district (McLemore et al. 1996; USGS 2011a).

The Afton SEZ land crosses none of the mineralized areas or historical mining districts listed above, and there has been no hard rock or locatable mining activity within the site. Most of the locatable minerals in the region come from the Organ Mountains, bordering the east side of Mesilla Valley, where the major deposits include copper, lead, zinc, silver, and gold. Other minerals include barite, fluorite, uranium (co-occurring with fluorite veins), vanadium, and bismuth. These deposits are associated with the many intrusions making up the Organ batholith, including the granite of Granite Peak, the Sugarloaf Peak quartz monzonite, the Organ Needle quartz syenite, and numerous rhyolite dikes. Comparable units, if below the SEZ, are buried by basin-fill sediments that are up to 3,000-ft (915-m) thick. The occurrence of mineralized zones below the site is unconfirmed, but based on geologic studies to date, they are likely to be very deep (below basin sediments) if present. Therefore, the potential for locatable minerals to occur within the SEZ is low (level of certainty B).

2.7.2 Saleable Mineral Materials

Saleable mineral materials in the region include scoria, sand and gravel, brick clay, and stone (crushed stone, travertine, calcite, limestone, and marble). Scoria has been produced from the volcanic rocks (geologic map unit Qb) of Little Black Mountain to the east of the Afton SEZ and Santo Tomas Mountain to the northeast. Stone and gravel have been mined to the northwest of the SEZ. According to the USGS MRDS, sand and gravel are still mined in alluvium at the Lazy-E Pit, about 4 mi (6.4 km) to the northwest (in sections 32 and 33 of T23S, R2W). There is also a sand and gravel pit located across I-10, several miles to the north of the site (USGS 2011a). There are no active free use permits or mineral materials contracts within the SEZ (BLM 2012). A small operation (NMNM 089309) produced pumice and scoria (volcanic cinder) on 20 acres (0.081 km^2) at the east end of the site just south of Little Black Mountain (in section 25 of T25S, R1E) until 1995; a free use permit (NMNM 106213) for sand and gravel (in section 21 of T25S, R1E) was closed in 2002 (BLM 2012).

The Afton SEZ lies within the Aden District, an industrial mining area producing volcanic materials (mainly scoria) used in making cinder block and concrete. There are more than 150 cinder cones (including Aden Cone) in the Aden District (McLemore et al. 1996). There is also an area known as Kilbourne Hole located about 4 mi (6.4 km) to the south of the SEZ (in section 10 of T26S, R1W; see Map 1) that is popular with amateur collectors of gems (mainly peridot, a gem variety of olivine); however, no commercial production occurs at the site (Smith 2012b).

The Afton SEZ is an area with high potential for the occurrence of sand and gravel, pumice, and scoria (level of certainty D). Although there are currently no free use permits or mineral materials contracts within the SEZ, past mining of sand and gravel, pumice, and scoria within the SEZ indicates that future extraction of such deposits within the SEZ is viable.

2.7.3 Leasable Minerals

There is no history of production for coal, potassium, sodium, phosphate, or oil shale on public lands in Doña Ana County, and the geologic environment is not considered favorable for these resources. However, the region is considered prospectively valuable for oil, gas, and geothermal resources (BLM 2008).

The potential for oil and gas development within the Afton SEZ is low (level of certainty B). There are no active oil and gas leases within the SEZ. Most of the area in the southeastern portion of the site (in T25S, R1W and T25S, R1E) was leased at one time, but these leases were closed in the mid- to late-1980s (BLM 2012). According to the State of New Mexico Oil Conservation Division (NMOCD), there is no history of oil or natural gas production in Doña Ana County (NMOCD 2012). (Most of the oil and gas production in New Mexico is from the Permian Basin in the southeastern part of the state and west Texas [Broadhead et al. 2004]). Several test wells have been drilled in the county since the 1950s. One well, No. 1 Mobil 32, was drilled into the Mesilla Basin on the West Mesa to a depth of 21,759 ft (6,632 m), penetrating thick sections of Cenozoic, Mesozoic, and Paleozoic strata; several shows of oil and gas were logged in this well (Thompson 1982). Potential reservoir rocks in the Mesilla-Mimbres Basins region are still under study; oil- and gas-bearing units may include Ordovician carbonates of the El Paso and Montoya Dolomite Groups, the Silurian Fusselman Formation, and the Cambrian-Ordovician Bliss Formation, a quartz sandstone (Butler 2012).

The Las Cruces District is an area of high geothermal potential (BLM and EERE 2003; INEEL 2003); however, there are no active or historical geothermal leases and no nominated lands for geothermal sale within the site. Most of the geothermal resources in the region are concentrated on East Mesa near Tortugas Mountain, about 15 mi (24 km) to the northeast of the SEZ (see Map 1) and trending southward along I-10 and I-25 nearly to the New Mexico–Texas state line. The geothermal system in this region (called the Las Cruces East Mesa system) sits above a buried horst block of mid-Tertiary volcanics and Paleozoic carbonates (Lohse and Iceman 1982). It is one of the largest "convective" low-temperature (i.e., <90°C [<194°F]) geothermal systems in the United States, with reservoir temperatures ranging from 40 to 70°C (104 to 158°F) (Witcher 1995). Reservoir temperatures in the vicinity of the Afton SEZ, however, are typically less than 40°C (104°F); for example, at Kilbourne Hole, temperatures were found to be about 38°C (100°F) at a depth of 180 ft (55 m), and in wells to the northeast, temperatures were less than 35°C (95°F) at a depth of about 380 ft (115 m) (Smith 2012b). For this reason, the potential for development of geothermal energy within the SEZ is low (level of certainty B).

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4 LIST OF PREPARERS

Table 3 lists the BLM management team members and technical reviewers for this assessment. Table 4 lists the names, education, and expertise of the report preparers.

TABLE 3 BLM Management Team and Mineral Specialists Consulted

Name	Office/Title
Linda Resseguie	Minerals and Realty Management Directorate, Realty Specialist
Shannon Stewart	Renewable Resources and Planning Directorate, Senior Planning and Environmental Analyst
Jeff Holdren	Division of Lands, Realty and Cadastral Survey, Senior Realty Specialist
Matt Shumaker	Division of Solid Minerals, Chief Mineral Examiner
Jason Powell	Division of Solid Minerals, Geologist
Michael Smith	Las Cruces District Office, Geologist

TABLE 4 Report Preparers

Name	Education/Expertise	Contribution
Linda Graf	Desktop publishing specialist; 41 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Heidi Hartmann	M.S., Environmental Toxicology and Epidemiology; 25 years of experience in environmental assessment, exposure and risk analysis, and environmental impact assessment.	Solar PEIS Project Manager
Irene Hogstrom	M.A. Geography and Environmental Studies; B.L.A., Landscape Architecture; 23 years of experience in landscape architecture, including design, regional planning, and ecological restoration.	LR2000 queries
Patricia Hollopeter	B.A., Religion; M.A., Philosophy; 27 years of experience in technical editing and environmental assessment document production.	Editor
James E. May	M.S., Water Resources Management, B.A., Zoology; 34 years of experience in natural resources management; 8 years of consulting experience in resource management, land use planning, and NEPA compliance.	Lands and realty; and mineral review
Greg McGovern	M.S., B.S., Geology (Hydrogeology); 23 years of experience in environmental site assessment and contaminant fate and transport studies.	Site-specific geology
Mary R. Moniger	B.A., English, 35 years of experience in editing and writing.	Lead editor
Michele Nelson	Graphic designer; 35 years of experience in graphical design and technical illustration.	Report cover design and foldout map layout
Terri L. Patton	M.S., B.S., Geology (Igneous Petrology and Mineral Chemistry); 24 years of experience in environmental research and assessment.	Lead author; geology and mineral assessment
Kurt Picel	Ph.D., Environmental Health Sciences; 33 years of experience in environmental health analysis and 18 years in environmental assessment.	Environmental analysis and review
Lorenza Salinas	Desktop publishing specialist; 30 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production

TABLE 4 (Cont.)

Name	Education/Expertise	Contribution
Barbara Simmons	B.A., Technical Writing; E.L.S. certification by the Board of Editors in the Life Sciences; Fellow, Society for Technical Communication; 45 years of experience in technical editing and publications management.	Editor
Karen P. Smith	M.S., B.A., Geology; B.S., Anthropology; more than 23 years of experience in energy and environmental regulatory and policy analysis.	Solar PEIS Program Manager
Emily A. Zvolanek	B.A., Environmental Science; 4 years of experience in GIS mapping,	GIS mapping

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