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July 2, 2013

Holland Shepherd, Program Manager
Mining Act Reclamation Program
Mining and Minerals Division
Department of Energy, Minerals, and Natural Resources
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Mr. Shepherd:

Santa Fe Gold Corporation and GL Environmental, Inc. are pleased to present herewith our Sampling and Analysis Plan for the Ortiz Mine. Please do not hesitate to contact me or Tim Leftwich or Denise Gallegos of GL should you have questions or require additional information. We look forward to receiving your comments on the Plan.

Yours sincerely,

Ryan P. Carson

Ryan P. Carson
Corporate Secretary

Sampling and Analysis Plan For the Ortiz Mine

PREPARED FOR:

SANTA FE GOLD A Mining & Exploration Co.

BY:

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1 Introduction

1.1 Project Background

The Ortiz Mine Grant in Santa Fe County New Mexico is one of the oldest mining areas in New Mexico and in the United States. The prospecting and mining of gold and silver in the Ortiz area dates to the arrival of the first European settlers in 1598. Significant gold production from Ortiz placer deposits dates to 1821. By 1832, several veins and low-grade gold deposits had been discovered.

Its legal status derives from the granting of surface and mineral rights of an approximately 16 km by 16 km (10-mi by 10-mi) tract to Francisco Ortiz by the First Alcalde of the City of Santa Fe in 1832 (Maynard 2013). The Ortiz Mine Gant was made for the specific purpose of facilitating gold mining. In 1848, Articles VIII and IX of the Treaty of Guadalupe Hidalgo between the United States and the Republic of Mexico recognized and protected the private property rights in the Ortiz Mine Grant and other Spanish and Mexican grants, providing that those rights would be "inviolably respected" against attempts to interfere with their exercise by either the original grantees or their successors. With the exception of a brief period in the 1940s described in the following paragraph, the land comprising the grant has remained in private hands since the grant's original designation. By the early 1840's, mining at the small underground Ortiz Mine had ceased.

Because of title issues and business failures, the Ortiz Mine Grant eventually ended up in the hands of the United States government, and in 1943, the grant was sold for grazing purposes to the Ortiz Cooperative Livestock Association, which was funded by the United States Farm Security Administration. However, the association never made any of the mortgage payments, and in 1946 the grant was sold at auction, except for the northeast quadrant of approximately 15,000 acres, to Mrs. George Potter of Joplin, Missouri. Mrs. Potter was from a mining family from the lead-zinc mining belt in Southwestern Missouri and Northeastern Oklahoma and, recognizing that the Ortiz Mine Grant was an historic mining area in which mining rights were protected by the Treaty of Guadalupe Hidalgo and which had good potential for additional mining, purchased the Grant for mining. The Potters sold limited surface rights of 57,270 acres to Howell Gage, W. L. McDonald, and Frank Young in 1947. Because Mrs. Potter had purchased the Ortiz Mine Grant for mining, when the Potters sold limited surface rights in 1947, they reserved all minerals and mining rights with the following reservation set out in their deed: "'[T]he first parties [that is, the Potters] hereby reserve unto themselves and to their heirs and assigns, all the oil, gas, coal, metals and minerals, in, on, or under the surface of the lands and real estate hereby conveyed, and all the rights of ownership therein, and reserve to themselves. their heirs and assignees, the right and license of exploring, mining, developing or operating, for any, or all of said products, upon said lands, and of erecting thereon all necessary buildings, pipe lines, machinery and equipment necessary in and about the business of mining, developing, or operating, for any of said products, to the same extent and with the full rights of an owner operating on his own land." The rights reserved by the Potters are consistent with New Mexico law, which recognizes that mineral and mining rights are dominant over surface rights and that mineral owners and lessees have the right to use as much of the surface as is necessary for their mining operations (*Kysar v. Amoco Production Co*., 2004 -NMSC-025, § 24, 135 N.M. 767, 93 P.3d 1272). In 1959, the Potter family and associates formed Ortiz Mines, Inc. to facilitate mining on the Ortiz Mine Grant. Santa Fe Gold Corporation holds its mining rights under a lease from Ortiz Mines, Inc.

Consolidated Gold Fields developed the first mine on the Cunningham Hill deposit on the eastern half of the Ortiz Land Grant, producing approximately 250,000 ounces of gold between 1979 and 1986 (Maynard 2013). Total pre-1979 mine production has been estimated at about 100,000 ounces of gold.

From 1972 through the early 1990's, several companies operating under lease with Ortiz Mines, Inc. carried out exploration and pre-development activities in the southern portion of the Grant. These companies included Conoco, Inc., LAC Minerals (USA), Inc. and the LAC-Pegasus Joint Venture. Expenditures by these groups are estimated to have exceeded $40 million. Drilling resulted in the identification of gold mineralization in several deposits.

The LAC-Pegasus Joint Venture carried out the majority of their work in the southern portion of the Grant, from 1989-1992. The Joint Venture focused on two deposits, namely the Carache Canyon ("Carache") and Lukas Canyon ("Lukas") deposits. These two deposits were the subject of 386,000 feet of core and reverse-circulation drilling, metallurgical testing and pre-feasibility studies.

In 1989, the LAC-Pegasus Joint Venture started a decline adit into the Carache deposit for the purpose of bulk sampling and to provide drilling access for shallow and deep exploration targets. However, after advancing 1,719 feet the decline was halted due to a temporary water inflow coupled with regulatory and permitting issues. In the face of a declining gold price, mining development of the Carache or Lukas deposits did not proceed, and the project ultimately was cancelled and the lease released back to Ortiz Mines, Inc.

In August 2004, Santa Fe Gold acquired exclusive rights for exploration, development and mining of gold and other minerals on 57,267 acres (approximately 90 square miles) of the Ortiz Mine Grant. In November 2007, Santa Fe Gold relinquished 14,970 acres and retained under lease 42,297 acres (66 square miles).

In November 2005, using historical resources and pit designs, the results of an independent scoping study for open pit mining indicated approximately one million ounces of minable gold in the Carache and Lukas gold deposits. The geology of the unusually large area under Santa Fe Gold's control is prospective for several types of gold deposits and offers promising exploration potential for discovery of additional deposits.

1.2 Applicant Information

- Name of permit applicant:

Santa Fe Gold Corporation

- A map of the proposed permit area (on a USGS topographic map) is presented below (Figure 1-1. Proposed Permit Area).
- A map showing all known surface owners of surface and mineral estates within the proposed permit area is presented below (Figure 1-1. Proposed Permit Area).
- Owners of surface and mineral estates within the proposed permit area is presented below (Table 1-1. Surface and Mineral Estate Owners):

Table 1-1. Surface and Mineral Estate Owners

Estate	Name	Owner
Surface	Lone Mountain Ranch	Lone Mountain Ranch, LLC c/o Mary L. Estrin 1717 Westridge Road Los Angeles, CA 90069
Surface	Rancho de Chavez	Control Systems Properties, LLC c/o Steven B. Chavez 4020 Vassar Drive NE Albuquerque, NM 87107
Fee Mineral	Ortiz Mine Grant	Ortiz Mines, Inc. c/o Anne Russ 14103 Pembroke Leawood, KS 66224
Patented Mineral/Surface	Black Prince Illinois Ohio Lukas Millsite	Potter/Ortiz, LLC c/o Anne Russ 14103 Pembroke Leawood, KS 66224

- Parties that have an ownership and controlling interest in the operation:

Santa Fe Gold Corporation
6100 Uptown Blvd., Suite 600
Albuquerque, NM 87110
505-255-4852

- The contact information for the applicant's designated agent:

W. Pierce Carson
6100 Uptown Blvd., Suite 600
Albuquerque, NM 87110
505-255-4852

1.3 General Mining Plan

1.3.1 Mining Operations

Planning for the Ortiz mine is still under evaluation at the time of this writing. Optimization of the mine from economic and engineering perspectives will continue during the sampling and analysis period.

The current plan proposes to develop the Carache deposit as conventional open pit mine with 45° (1H:1V) overall pit slope angles, including allowance for haul roads. The stripping ratio of the pit is approximately 8.5 to 1. The Carache deposit will be developed by a single elongated inverted cone shaped pit with the ultimate pit depth about 600 ft. from the south pit rim, which is the lowest point on the rim. The highest wall, on the north side, would be approximately 1,060 ft.

Non-ore rock materials from Carache under this plan would be placed into the adjacent canyon southwest of the pit. The configuration of the Carache pit precludes any significant backfill in Carache during the commercial operation period. Figure 1-2 provides a conceptual layout of the pits and non-ore removal piles.

Mining equipment assumed in the preliminary feasibility includes two Hitachi EX2500 hydraulic shovels of about 20 cubic yards (cu yd) capacity and a Caterpillar 992 wheel loader with a 14 cu yd capacity. This equipment will load moderate sized off-road haul trucks such as the Caterpillar 777 trucks (100 ton capacity). Drilling equipment would include three Caterpillar MD6240 blast hole drills capable drilling 6 inch to 8 inch diameter holes. Ultimate hole diameter, spacing and depths will be determined to optimize rock fracturing while minimizing vibration levels. A small fleet of track dozers, wheel dozers, motor graders, and water trucks would be employed to maintain mining areas, stockpile areas and roads. There will also be smaller support equipment and vehicles.

Approximately 13.2 million tons of ore grade material is planned to be extracted and processed. The operation is presently being designed to process 1.5 million tons per year. This gives the mine a commercial life of about 9 years after the construction and development period. Total material to be moved combining both ore and non-ore is approximately 125 million tons.

1.3.2 Milling operations

The milling process for the ore material currently includes plans for crushing, grinding, gravity separation, and dry stacking of tailings material. Cyanide and other forms of chemical leaching are not proposed as part of the milling and concentrating process. The throughput capacity of the milling and concentration process will be approximately 4,500 tons per day or 1.5 million tons per year.

A conventional crushing circuit will be employed that consist of a series of crushers in combination with a screening unit to reduce ore to ½ inch minus material. The crushed ore will be fed into a ball mill for further grinding.

Material discharged from the ball mill will undergo gravity concentration in centrifugal concentrators. Concentrates from the centrifuges will report to hoppers and will be smelted daily for production of doré metal. Slag generated in the gold smelter will be crushed and returned to the ball mill for reprocessing.

Mechanical stacking of dewatered tailings has been selected as the disposal technique for the tailings from the mill. Automated filter presses will be used to dewater the tails from the concentration process. Collection belts will convey filtered tails to a fixed conveyor for transport to the tailings stockpile area. A 250 foot radial stacker will used to distribute tails to a stockpile approximately 60 feet high through an arc of 135°. A bull dozer will be used to continuously level the pile and drift tails outward from the radial stacker. Two twenty cubic yard scrapers and additional equipment will be used to transport tailings in the stockpile area for deposition.

The tailings stockpile area is located south of the plant and is comprised of a final area of approximately 106 acres. An estimated drawing of the tailings stockpile area is presented in Figure 1-2. Deposition of tails will start at the south end of the stockpile. The tailings pile will be constructed with all outside faces held at 3H:1V slopes. All outside slopes will be reclaimed to provide stabilization against erosion as soon as they reach their final elevation.

1.3.3 Water Resources

Currently water needs for the project are expected to be 215 acre feet per year. Use of water for the duration of the project is expected to be approximately 10 years. Water required for operation of the mine and mill will be obtained from one or a combination of several options. The options include the lease or acquisition and transfer of water rights from local water rights holders, lease or acquisition and transfer of water rights from the Estancia Basin, lease or acquisition and transfer of water rights from Rio Grande surface water rights, or the completion of deep groundwater wells. The deep well(s) option would access water in the Cretaceous, Jurassic, Triassic, and Permian aged sequence of formations located several thousand feet below the ground surface in the vicinity of the project area.

1.3.4 Reclamation

Site stabilization and configuration will be designed to conform to the requirements of 19.10.6.603 NMAC, Performance and Reclamation Standards and Requirements.

The Carache pit rock dump's reconstructed slopes and embankments will be designed, constructed and maintained to minimize mass movement. Erosion control methods will include final slope contour gradients of 3H:1V where practicable, minimizing slope lengths, diverting drainage runoff away from the rock dumps, tailings stockpile, and haul roads.

The tailings stockpile located south of the milling plant encompasses approximately 106 acres and deposited to an average thickness of approximate 60 ft. Disposition of tails will start at the south end of the stockpile area and proceed to the north. The tailings pile will be constructed with final graded slopes of 3H:1V. As the final elevation is reached, all outside slope faces will be graded and revegetated to provide both wind and water erosional stability.

Backfilling of the Carache pit is not contemplated in the current mining scenarios.

Constructed drainage diversions are being designed to divert runoff away from the Carache rock dump and the mill/tailings area. These diversions will be designed with the appropriate channel lining such as riprap/rock, vegetation or geotechnical materials to control channel erosion and regulate water velocity.

Opportunities for contemporaneous reclamation are being evaluated in the mine plan options. Where practicable, when portions of rock dumps, tailings stockpiles, and other impacted areas reach final elevation and grade, they will be topsoiled, topdressed and revegetated.

During the sampling and analysis process, soil surveys will focus on identifying the location and volume of topsoil material. If sufficient topsoil is located in the disturbed or borrow areas, it will be collected, stockpiled and stabilized to prevent loss from wind or water erosion. The topsoil and topdressing material will be distributed over the reclaimed areas for revegetation. Revegetation methods will include seed bed preparation, mulching, seeding, and monitoring.

1.4 SAP Summary

This sampling and analysis plan (SAP) has been prepared for Santa Fe Gold Corporation and submitted to the New Mexico Energy, Minerals and Natural Resources Department (EMNRD) Mining and Minerals Division (MMD) as the first phase in the new, non-coal mine permitting process pursuant to 19.10.6 NMAC (New Mexico Administrative Code). The SAP provides the sampling and analysis procedures for data to be included in the baseline characterization report submittal as part of the mine permit application, the second phase of the mine permitting process. Baseline data will include the hydrologic, geologic, mineralogy, ecologic, and cultural components within the proposed permit area and the area outside of the permit area that will be affected by the proposed activity at the Ortiz Mine.

Pursuant to Paragraph 13 of Subsection D of 19.10.6.602 NMAC, this SAP contains ten data subcategories, which are further described in Tables 1 and 2 of the MMD draft guidance document (MMD, 2010). These subcategories and their location in this SAP are listed below.

- Climatological factors (Section 2)
- Topographic maps (Section 3)
- Vegetation survey (Section 4)
- Wildlife survey (Section 5)
- Topsoil survey/sampling (Section 6)
- Mineralogical and geological description of ore body (Section 7)
- Surface and groundwater (Section 8)
- Historic and cultural properties survey (Section 9)
- Description of historic and present land use **AND** Prior mining operations (Section 10)

An 11^{th} subcategory, radiological survey, is not required for non-uranium mines.

This SAP presents the data requirements identified for each subcategory and describes how these will be addressed, summarizes the sampling objectives, and describes the data collection methods for each subcategory or medium. Specifically, in accordance with Subparagraph (a) of Paragraph (12) of Subsection D of 19.10.6.602 NMAC, the following information is discussed for each of the ten subcategories:

- Sampling objectives
- Sampling frequency (in accordance with Table 2 of the 2010 MMD guidance for new mining operations)
- A list of data to be collected
- Methods of collection
- Parameters to be analyzed (as outlined in Table 1 of the 2010 MMD guidance)
- Maps showing proposed sampling locations
- Laboratory and field quality assurance plans
- A brief discussion supporting the proposed sampling plan and/or use of historical data

Where the methods of collection require the use of a Global Positioning System (GPS) receiver to record site features (e.g., discrete sampling locations, transect locations, surface drainage features, weather station locations, cultural resource locations, etc.), those data will be collected at sub-meter accuracy . They will then be verified by reference to landscape features shown on georeferenced aerial photography and landmarks shown on USGS quadrangle maps. Maps of these features will be created using ArcGIS. The maps and GPS data will be presented in a baseline summary report in report figures. The data can also be submitted in digital format as Microsoft Excel tables and/or ESRI shapefiles.

Previous site characterization activities have been performed at the Ortiz Mine as a result of past exploration activities. Historical data, when available, are summarized in the SAP and will be incorporated into the baseline data report along with new data that will be collected to meet the requirements of 19.10.6 NMAC. All new data collection will be performed in compliance with the procedures defined in the SAP and the Quality Assurance Project Plan included as Appendix C.

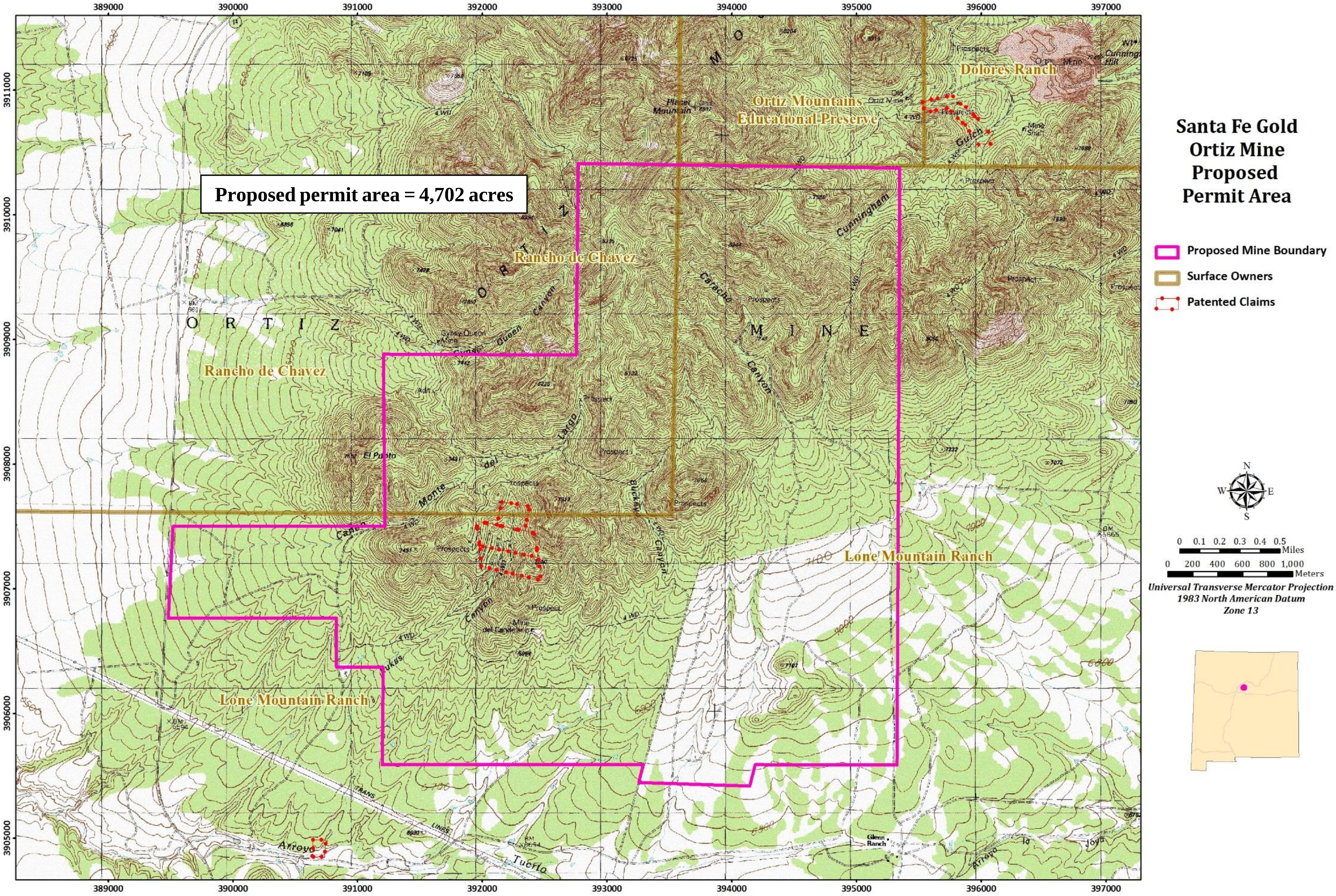


Figure 1-1. Proposed Permit Area

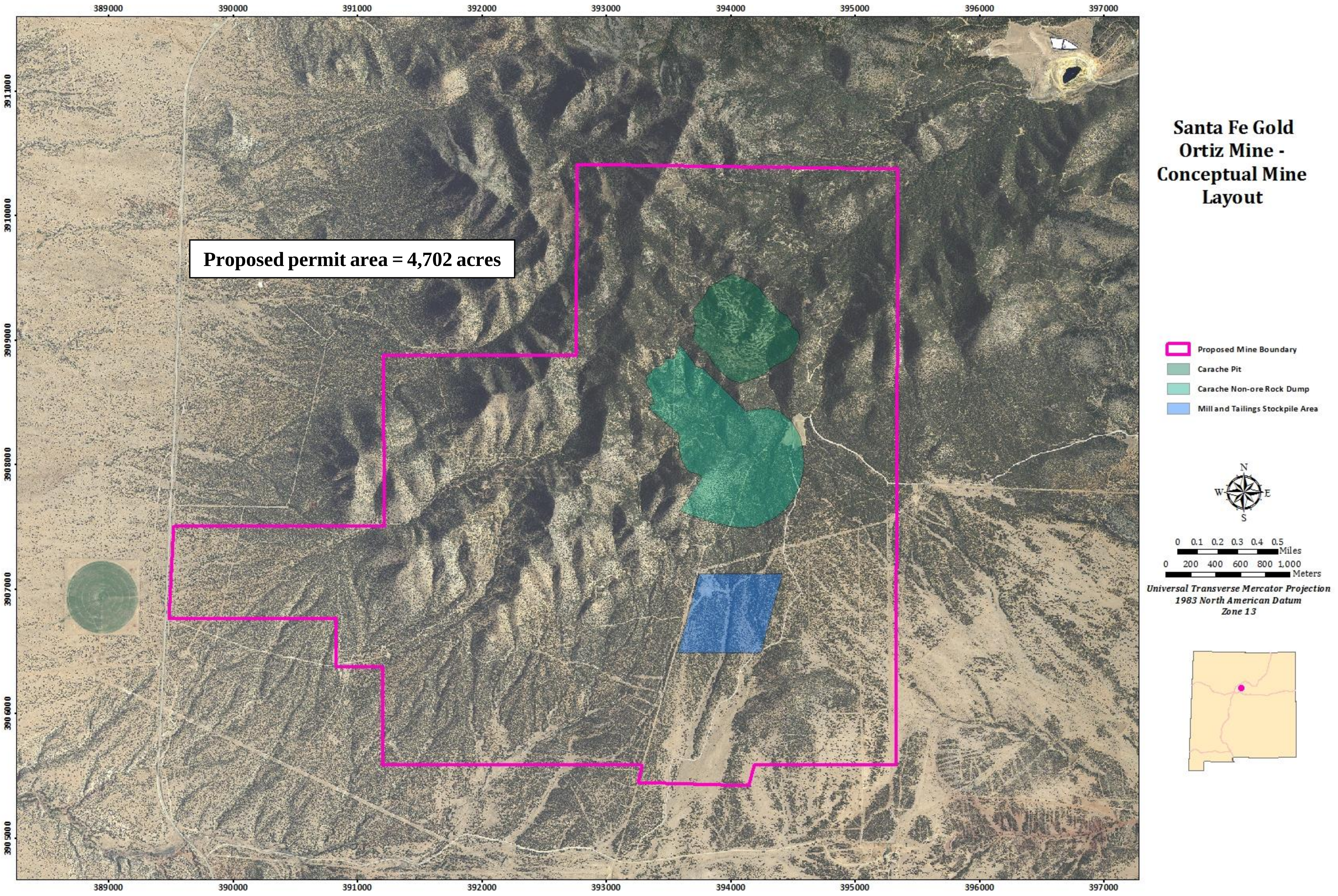


Figure 1-2. Conceptual Mine Layout

2 Climatological Factors

2.1 Introduction and Background

The Ortiz Project Site is located in the Central Highlands climatic division of New Mexico (NCDC 2013). Generally, the study area has mild semi-arid, continental climate characterized by low precipitation totals, abundant sunshine, low relative humidity, and a relatively large annual and daily temperature range.

The average annual precipitation for Golden, several miles southwest of the project site is 14 inches per year for the period 1945 – 2010. Wide variation in annual precipitation totals have been recorded at Golden. In 1956, the total precipitation was 4.1, the lowest recorded during the observed time period. The highest annual precipitation recorded at Golden was 22.8 inches in 1969.

Most of the annual precipitation falls during the summer monsoon season. Summer thunderstorms are usually brief but intense in nature and can vary widely in spatial distribution. Most winter precipitation occurs as snow.

2.2 Sampling Objectives

The purpose of the monitoring program will be to collect baseline climatological data representative of the site. The meteorological data will provide input for quarterly and annual averaging and trend analysis.

2.3 Sampling Frequency

The monitoring program will operate as a single station for a minimum of one year. Meteorological sensors are to be scanned once every 15 seconds. The data will be compiled as averages and totals at hourly and 15-minute intervals.

2.4 List of Data to be Collected

- Wind direction
- Wind speed
- Temperature
- Relative humidity
- Barometric pressure
- Solar radiation
- Precipitation

2.5 Methods of Collection

The meteorological sensors will be installed on a 2m tower. The meteorological (met) station is proposed in open terrain to record accurate wind speed and direction. Open terrain is defined as an area where the distance between the instrument and any obstruction is at least ten times the height of that obstruction. The ground cover at the proposed location is native vegetation consisting of annual forbs, perennial bunch grasses, and perennial low growing shrubs. The precipitation gauge will be located low to the ground where native vegetation will provide adequate wind dissipation for accurate measurement. Temperature and humidity instruments will be protected from thermal radiation (from the earth, sun, sky, and any surrounding objects) and adequately ventilated. The radiation sensor will be located with an unrestricted view of the sky in all directions during all seasons.

Data will be transmitted from the sensors to a data logger. The data logger will interface with a digital cellular modem allowing daily data downloads to a remote PC and monitoring of real-time meteorological conditions.

2.6 Parameters to be Analyzed

- Horizontal wind direction
- Horizontal wind speed
- Sigma theta of the wind direction
- Temperature
- Relative humidity
- Barometric pressure
- Net radiation
- Precipitation
- Pan evaporation

2.7 Maps Showing Proposed Sampling Locations

See Figure 2.1, Met Tower Location

2.8 Laboratory and field Quality Assurance Plans

The tower-based meteorological sensors will be audited every six months. Corrective action will be taken immediately to address problems identified during the audits. All audit results will be summarized in a separate report to be issued following each field visit.

The sampling and analysis methods proposed for climatological data acquisition for the Ortiz Project Site will be described in detail in the associated GL Environmental, Inc. Administrative Standard Operating Procedures (SOPs), Equipment SOPs, and Field SOPs. These documents establish procedures for quality related activities and ensure compliance the GL Environmental, Inc. Quality Policy. The Quality Policy is documented within the Quality Assurance Program Manual and execution of the system is described in the Quality Assurance Implementation Plan (Appendix C).

Additionally, any vendors that provide analytical data are procured through the use of a Quality Assurance Purchase Order (PO). This document requires the vendor to adhere to, at a minimum, GL's quality assurance program as well as any specifications required by the client.

2.9 Discussion Supporting the Proposed Sampling Plan

The purpose of the monitoring program will be to collect baseline climatological data representative of the Site over a one year period.

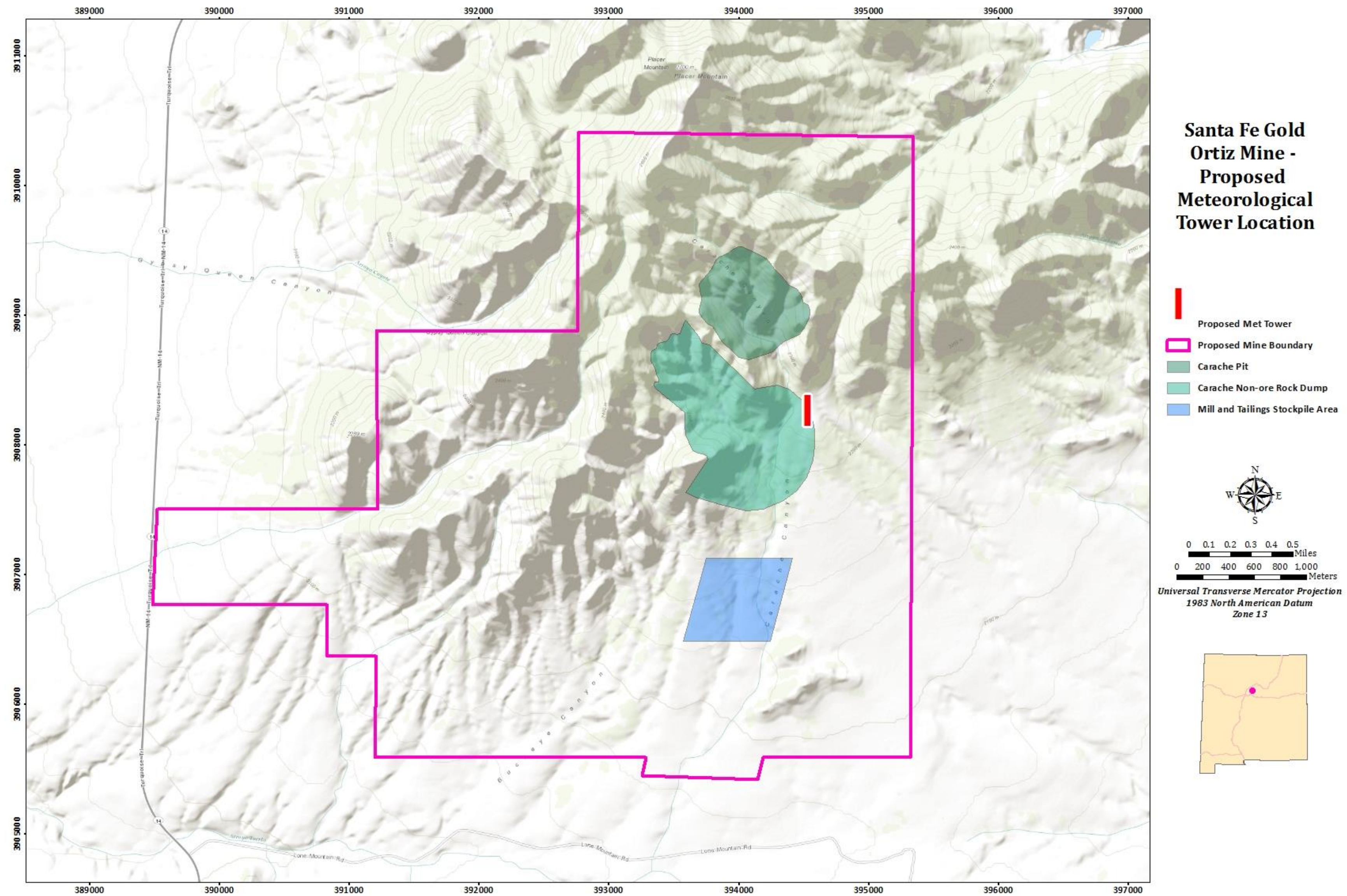


Figure 2-1. Proposed Meteorological Station Location

3 Topography

3.1 Introduction and Background

The LAC-Pegasus Joint Venture carried out extensive work focused on the Carache and Lukas deposits from 1989-1992. These two deposits were the subject of 386,000 feet of core and reverse-circulation drilling, metallurgical testing and pre-feasibility studies carried out by the LAC-Pegasus Joint Venture and by consulting firms and contractors engaged by the Joint Venture. However, the project ended before substantial alteration of surface topography occurred.

3.2 Sampling Objectives

The objective of the proposed data collection is to supplement existing topographic data and verify the existence, condition, and use of features within and immediately around the proposed site before mining operations commence. These baseline data will assist in the design of the facility and the reclamation and replacement of features.

3.3 Sampling Frequency

Supplementation and verification of existing topographic data will occur simultaneously with other field surveys, e.g. vegetation and soil surveys, remote sensing used for mine design.

3.4 List of Data to be Collected

- GPS data of sampling locations
- Observations of new or altered topographic conditions
- Elevation data for engineering design and surface hydrology

3.5 Methods of Collection

- Aerial photography
- GPS
- Annotation
- Remote sensing (satellites), where practicable

3.6 Parameters to be Analyzed

- New aerial photographs will be flown and the appropriate interval contour maps will be developed as needed for engineering design.
- Stream bed contours will be defined in more detail, including channel plan, profile, and cross-section using aerial photographs and/or conventional survey techniques.
- Baseline topography
- New or altered topographic features

3.7 Maps Showing Proposed Sampling Locations

Maps showing proposed sampling locations are included within each data subcategory section.

3.8 Laboratory and field Quality Assurance Plans

Digitized aerial photographs and derived contours will be used for design, baseline data presentation, and baseline conditions for reclamation and re-vegetation. These data are often downloaded from the Resource Geographic Information System (RGIS) Clearinghouse, a repository for New Mexico digital, geospatial data acquired from local and national public agencies or created expressly for RGIS. The data are publicly available and most files can be downloaded from the RGIS ftp web site. The data available on this site have been acquired over a number of years from a variety of public sources, such as the New Mexico BLM office, USGS, and the Bureau of the Census. Little has been created by RGIS Clearinghouse personnel. For these and other reasons, there is considerable variation in the quality and accuracy of the data. RGIS Clearinghouse has processed these data to check for attribute consistency and topological errors and to bring everything into a common projection, but not all shortcomings in the data could be overcome. Thus, each source of data will be evaluated independently according to the GL Environmental, Inc. Quality Policy. The Quality Policy is documented within the Quality Assurance Program Manual and execution of the system is described in the Quality Assurance Implementation Plan (Appendix C).

3.9 Discussion Supporting the Proposed Sampling Plan

Topographic sampling largely involves processing on-the-ground observations against existing topographic data. These “ground-truthing” activities are critical for the SAP since the baseline topographic data provide a framework for all other sampling.

Collection of more accurate elevation data will help determine the location of various elements of the facility as well as the planning and design of grading, mitigation measures for surface drainage, and reclamation.

4 Vegetation

4.1 Introduction and Background

There are areas within the proposed permit boundary that are both relatively undisturbed and substantially disturbed as a result of earlier mineral exploration and other activities such as utility installations and grazing. Additionally, drill pads and access roads constructed for exploration were seeded with a mix of cool and warm season grasses and forbs (Table 4-1) (Elliott 1991). Therefore, the existing vegetation community conditions, and consequently baseline conditions, likely reflect these activities rather than any naturally occurring climax community type (Clements 1916, Barbour *et al.* 1987).

Table 4-1. Exploration seed mix

Species (common name)	Pure Live Seed (lbs per acre)	Period of Growth

Pascopyrum smithii (western wheatgrass)	6.0	Cool season
Pseudoroegneria spicata (bluebunch wheatgrass) or *Pseudoroegneria spicata* ssp. *inermis* (beardless bluebunch wheatgrass)[1]	4.0	Cool season
Pleuraphis jamesii (galleta grass)	1.0	Warm season
Thinopyrum intermedium (pubescent wheatgrass)	1.0	Cool season
Achnatherum hymenoides (Indian ricegrass)	1.0	Cool season
Bouteloua curtipendula (side-oats grama)	5.0	Warm season
Bouteloua gracilis (blue grama)	3.0	Warm season
Sporobolus cryptandrus (sand dropseed)	0.5	Warm season
Melilotus officinalis (yellow sweetclover)	1.5	Cool season
Astragalus cicer (Cicer milkvetch)[2]	1.0	Cool season
Total	24.0	

[1]Used singly or in combination.
[2]Cicer milkvetch was not included in all revegetation efforts.

A vegetation survey of the proposed mine areas was performed in the early 1990's (Elliot 1991). A comprehensive inventory was completed as well as searches for plants considered sensitive by the New Mexico Natural Heritage Program and the New Mexico Energy, Minerals, and Natural Resources Department in 1990. 50 transects, including both native and revegetated sites, were sampled for quantitative vegetation characteristics. 231 species of plants and seven plant communities were identified. Of the five species considered sensitive or priority species in 1990, Elliot observed three: Wright's fishhook cactus (*Mammillaria wrightii*), daggerthorn cholla (*Grusonia clavata*; previously *Opuntia clavata*), and Santa Fe milkvetch (*Astragalus feensis*). Three noxious weed species were identified in the 1991 study (*Cardaria draba*, *Convovulus arvensis*, and *Solanum elaeagnifolium*), but none formed extensive infestations. At the time of the survey, surface preparation and re-seeding of areas disturbed by exploration drilling had begun; Elliot (1991) observed the establishment of both warm-season and cool-season grasses and the colonization of native forbs, grasses, and shrubs. Productivity of the site as a whole was characterized as limited by 1) overstory competition with woody plants and 2) shallow rocky soils.

4.2 Sampling Objectives

The proposed sampling and analysis plan is intended to describe existing vegetative conditions at the Ortiz Mine by achieving the following objectives:

- Characterize vegetation quantitatively by sampling cover, diversity of plant life form, production, and woody plant density.
- Map vegetation communities within the proposed permit area based on quantitative vegetation characteristics as well as historical data and ecological site descriptions.
- Establish a reference or control area representative of geology, soil, slope, and vegetation in the permit area to which subsequent quantitative measures of vegetation can be compared and classified.
- Complete a plant species inventory.
- Perform a threatened or endangered species survey.

4.3 Sampling Frequency

Because of seasonal variation in flowering phenology and germination, especially for annuals, a single inventory will likely not suffice. Thus, inventories will be timed so that GL can both locate and positively identify target plant species in the field. A survey beginning in late April 2013 is ongoing. Intensive quantitative data collection will be performed during the late summer following monsoons to accurately capture annual biomass production and peak vegetative cover. Because the mine is over 1000 acres in size and because the baseline data will ultimately be used to establish revegetation standards, a second year of field validation data will be collected in April and late summer of 2014 (NMEMNRD 1999).

4.4 List of Data to be Collected

- GIS data, including distributions of observed, historical, and published vegetation communities; transect locations; locations of threatened and endangered flora; disturbed areas and new areas to be disturbed; and other relevant ecological factors.
- For each vegetation type, species inventories and descriptions of topography, soil types and depths, average slopes, and aspects will be included as well as intensive quantitative data including:
    - Cover
    - Diversity of plant life form
    - Production
    - Woody plant density
- Plant species inventory by scientific and common names, and by life-form categories including annual grasses, perennial grasses, other graminoid species, annual and perennial forms, succulents, shrubs, sub-shrubs, and trees (NMEMNRD 1999).
- Inventory of threatened and endangered flora. There are no federally listed species recorded or likely to be found in the proposed project area, but two plants, tufted sand verbena (*Abronia bigelovii*) and Santa Fe milkvetch (*Astragalus feensis*), are listed as Species of Concern with vulnerable status on the New Mexico Rare Plant Website; populations have been recorded nearby (Clayton 1991). A records search will be undertaken to resolve the differences between the sensitive plants surveyed during the 1990 survey and those currently listed on the federal, state, and local databases. Finally, a brief report describing location, soils, habitats, and mitigation measures to be taken will be prepared for any species found within the proposed permit area.
- An inventory of all common and candidate weed species. Weeds will be noted as annual, biennial, or perennial weedy vegetative cover. If candidate weed species are observed in the proposed permit area, their locations will be noted, and when feasible, mapped as distinct vegetation types on the baseline vegetation map.

4.5 Methods of Collection

- Site characterization
- Location (GPS) data
- Pedestrian species inventory
- Line intercept
- Quadrats
- Belt transect

4.5.1 Categorization of site characteristics

Two major factors will determine how vegetation is categorized within the proposed permit boundary: variation in surface disturbance and topographic variation. These will in turn dictate the sampling effort required within each category. Because elevations range from 6,500 feet in the southern portion of the project area to 8,600 feet in the northern part, the permit boundary comprises both piñon-juniper woodland and juniper savanna (Dick-Peddie 1999). Additionally, two Natural Resources Conservation Service (NRCS) Major Land Resources Areas (MLRAs), which are somewhat parallel to the woodland and savanna vegetation types, converge within the permit boundary: the Southern Rocky Mountains MLRA and the Southwestern Plateaus, Mesas, and Foothills MLRA. Within the permit boundary, the Southern Rocky Mountains MLRA is differentiated by aspect and elevation; at lower elevations, it is found on north-facing slopes. At higher elevations near the extent of this ecological site, it is found on south-facing slopes (NRCS 2008). The Southwestern Plateaus, Mesas, and Foothills MLRA in the project area is characterized by lower tree density and the presence of shrubs such as chamisa (*Ericameria nauseosus*) and Apache plume (*Fallugia paradoxa*).

A 2x2 stratified random sampling design based on surface disturbance and vegetation type will be used for pre-mine vegetation mapping and quantitative data analysis. A transect density of one per 20 acres is generally considered adequate to accurately characterize quantitative vegetation data (Dave Clark, MMD, personal communication). Table 4-1 summarizes proposed sampling effort for each level of the sampling design.

Table 4-2. Vegetation community sampling

Vegetation Community	Acres	Number of transects
Juniper Savanna	2350	118
Juniper Savanna (disturbed)	64	3
Piñon-Juniper Woodland	2008	100
Piñon-Juniper Woodland (disturbed)	280	14
Total	4702	235

4.5.2 Pedestrian Survey

Since the GL botanist is familiar with the habitats of all the plant species that may reasonably be expected to occur in the project area, these surveys will be conducted in the style of an intuitive controlled survey (BLM Manual 6600). The project area is traversed thoroughly enough to see a representative cross section of all the major plant community types and topographic features. A species list of all plant taxa seen en route is compiled, the plant community or habitat type where each taxon occurs is recorded, and rare taxa locations are mapped by GPS. Areas where rare taxa are located or where data review indicates a high probability of occurrence are surveyed completely.

4.5.3 Quantitative vegetation transects

These procedures establish a method of vegetation sampling that will provide data about the distribution and identity of vegetation.

At each transect location in the field, a 100-ft measuring tape, subdivided into 1-ft intervals, and further subdivided into 0.1-ft intervals, is extended 100 feet in any haphazardly chosen direction. The location of the transect is determined by GPS and recorded.

To measure cover, the sampler moves along each transect, and for each 1-ft interval, records the number of 0.1ft intervals intercepted by each species. The sampler considers only the living parts of plants that vertically intercept the transect line, i.e. that are touched by, or are lying below or over the measuring tape. However, vegetation at all vertical levels is included in cover measurements. Plant matter along the transect that is not living is recorded as “litter”. The remainder of the transect line is considered “bare ground”.

To measure shrub density, the sampler moves along each transect, and for each side of the measuring tape records the number of each live shrub and woody species in a “belt” transected by a 3ft line perpendicular to the measuring tape. The shrub is considered to be within the belt if more than half of its basal area (stem or stems) is within 3ft of the measuring tape. The total area sampled is 600ft^2 per transect.

To measure production, a 0.25m^2 quadrat is placed at 0, 25, 50, and 75ft along each transect. At the first point, the sampler visually estimates the biomass contained within the quadrat in grams for each species. Then for each species, all living biomass is clipped, placed in a sampling bag marked with the transect location and species, weighed with a field scale, and the result recorded. The sampler then calibrates the visual estimation accordingly and records biomass for each of the 3 remaining points along the transect line. Clipped biomass is oven-dried and dry-weights for each field sample are recorded.

4.6 Parameters to be Analyzed

ArcGIS will be used to analyze geospatial data, i.e. acreage of areas characterized by vegetation type and surface disturbance, location data for rare species, and location data for quantitative vegetation transects.

Summary and analysis of the quantitative vegetation data collected will objectively and accurately estimate the following parameters: 1) percent area covered by vegetation, 2) percent area occupied by the identified species, 3) percent area occupied by the identified species relative to that of all other species, 4) density of identified shrub species, 5) an estimate of above ground plant biomass from the sampled area, and 6) a measure of diversity and richness of species occupying the sampled area.

4.7 Laboratory and field Quality Assurance Plans

In addition to being relatively standard methods of ecological sampling accepted by the MMD (NMEMNRD 1999), the sampling and analysis methods proposed for the Ortiz Mine are described in detail in the associated GL Environmental, Inc. GL Environmental Quality System Administrative Standard Operating Procedures (SOPs), Equipment SOPs, and Field SOPs. These documents establish procedures for quality related activities throughout the company and ensure compliance with regulatory requirements and the GL Environmental, Inc. Quality Policy. The Quality Policy is documented within the Quality Assurance Program Manual and execution of the system is described in the Quality Assurance Implementation Plan (Appendix C).

4.8 Discussion Supporting the Proposed Sampling Plan

The proposed vegetation sampling and analysis provides a methodology for accurately measuring and characterizing current vegetation at the Ortiz Mine and conforms to MMD sampling guidelines and objectives (2010). This information will be used to document baseline vegetation before mining operations commence, and will also provide reference areas in undisturbed portions of the permit area that may be useful in the future for gauging reclamation success and climatic or other disturbance-driven changes to vegetation in the permit area.

4.9 Maps and Figures

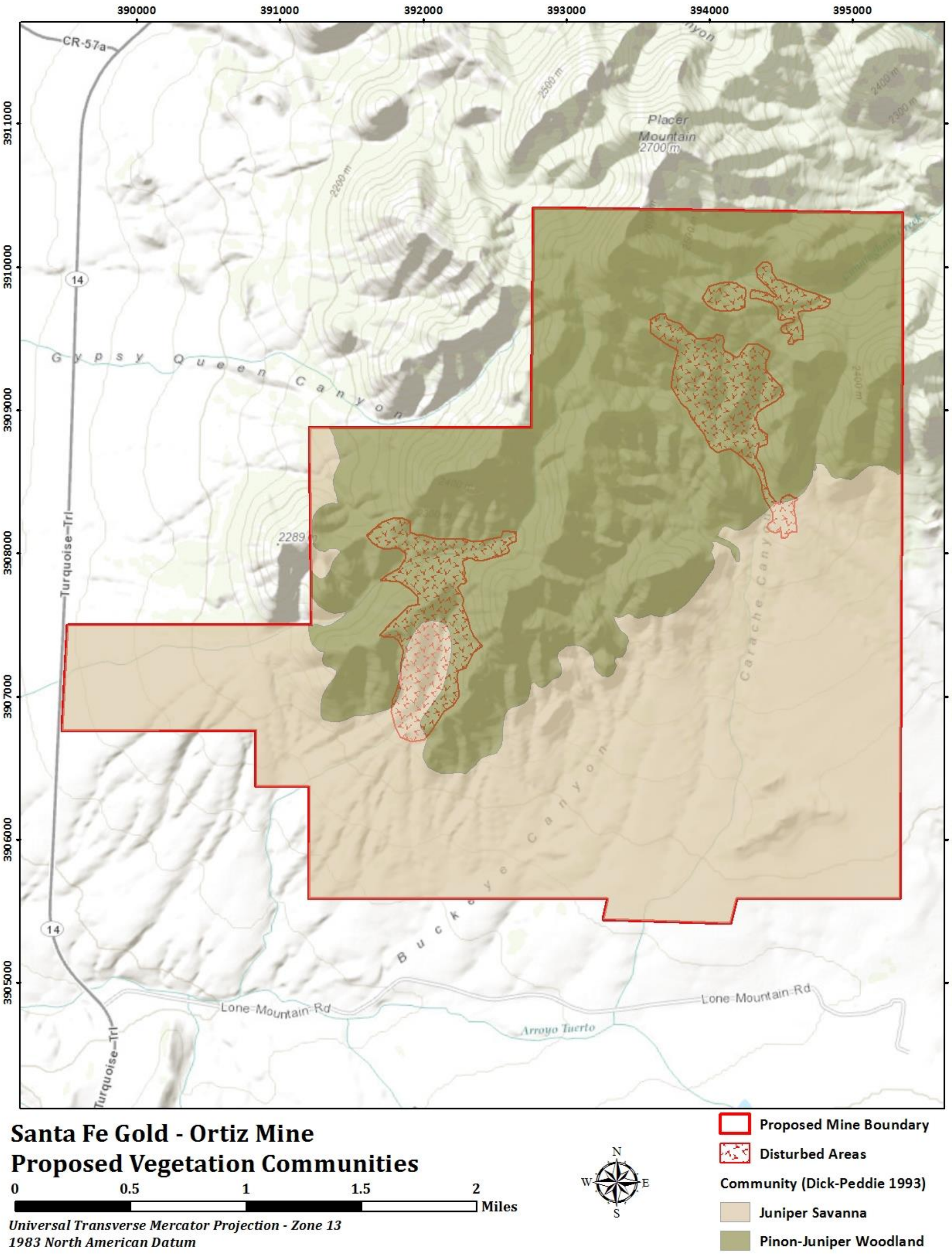


Figure 4-1. Vegetation Communities

5 Wildlife

5.1 Introduction and Background

A biological survey of the proposed mine area was performed in the late summer of 1990 (Metric 1991). Aerial photographs, topographic maps, field reconnaissance, and an analysis of how vertebrate wildlife would likely use food, cover, space, and interspersion resources were used to identify two topographic regions (mountains and alluvial plain) and four wildlife habitat sites (piñon-juniper woodlands, upper slopes, upland forest, and drainage) located within the current proposed project area. A fifth habitat site, intermittent stream, was identified, but its occurrences were located outside the current proposed project area.

5.1.1 Birds

53 species of birds were documented during the late summer 1990 survey with 33 species found in the alluvial plain and 38 species seen or heard in the mountain topographic region. Rufous-sided towhees were the most abundant species in both topographic regions (Metric 1991). A downward trend in frequency of occurrence of all birds was observed as breeding activity decreased toward the end of the summer. Three species of diurnal raptors were recorded during the study: red-tailed hawk, golden eagle, and sharp-shinned hawk.

5.1.2 Reptiles

The wandering garter snake, Western fence lizard, New Mexico whiptail, mountain short-horned lizard, and tree lizard were observed during the 1990 survey (Metric 1991). Western fence lizards were most common, occurring in all habitats identified. No amphibians were encountered during the survey period.

5.1.3 Non-volant mammals

- Small – small terrestrial (everything smaller than lagomorphs or the largest rodents) mammals easily caught in standard live traps
- Medium – small carnivores and large rodents detectable by non-trapping observational methods such as track censuses and camera arrays.
- Large – carnivores larger than a fox (bears, mountain lions, badgers, etc.), even-toed ungulates (antelope, deer, pigs, cows, sheep), odd-toed ungulates (horses)

Standard trapping and observational transect methods indicated a uniform distribution in numbers of total small mammals captured across all habitat sites except the intermittent stream habitat, which saw the greatest abundance and diversity of all small mammal species (Metric 1991). Species composition varied, however, across habitat sites; deer mice were ubiquitous, woodrats were found primarily in the piñon-juniper woodlands, and chipmunks and squirrels were the most common mammals found in the upland forest and upper slopes. Deer pellet transects indicated a preference for the upland forest and drainage habitats of the mountain topographic region during the late summer of 1990. Signs of cougar, black bear, and elk were noted in the upland forest habitat site outside (above Cunningham Canyon on the north side of the Ortiz Mountain range) the current proposed project boundary.

5.1.4 Volant mammals (bats)

There are 30 species of bats known to roost, hibernate, or otherwise reside in New Mexico. Of these species, two are legally protected by state or federal statutes. However, almost all of the bat species in New Mexico are considered Sensitive and potential impacts to them are typically well scrutinized. The Ortiz Mountains project site is unique in that it is situated in a region that contains ecological components from the northern mountains, western Great Plains, and high desert biomes. Given its location and the array of potential roost sites, as well as the relative abundance of available water, the project area likely supports a high diversity of bat species (Balistreri 2013). A brief pedestrian survey performed by J. Scott Altenbach in the early 1990s yielded a list of bat species and associated probabilities of occurrence (Table 5.1).

Table 5-1. Bat species and occurrence probability

Species	Occurrence probability
Antrozous pallidus	certain to use mine features
Plecotus townsendii	certain to use mine features
Myotis auriculus	likely to use mine features
Myotis ciliolabrum	likely to use mine features
Myotis thysanodes	likely to use mine features
Eptesicus fuscus	likely to use mine features
Lasionycteris noctivagans	likely to forage, drink in, or migrate through the area
Lasiurus cinereus	likely to forage, drink in, or migrate through the area
Myotis volans	likely to forage, drink in, or migrate through the area
Pipistrellus hesperus	likely to forage, drink in, or migrate through the area

5.2 Sampling Objectives

The proposed sampling and analysis plan is intended to describe existing wildlife conditions at the Ortiz Mine by achieving the following objectives:

- Delineate and map current wildlife habitat.
- Describe wildlife use of the area.
- Complete a bird species inventory.
- Complete a threatened or endangered species survey.
- Develop an inventory of species encountered during surveys or deemed likely to occur within the permit area.
- Estimate species distribution by habitat and season. Certain animals, especially birds, use specific habitats during different times of the year.
- Enumerate other key habitat areas observed (e.g., cliffs, talus slopes, ponds, springs, known nests).

5.3 Sampling Frequency

The proposed scope includes a minimum of two avian surveys over a 12 month period; once in December or January for overwintering bird species, once in late-May to early June for peak breeding season. Other groups of animals such as small mammals and reptiles will be surveyed during the summer 2013. Habitat features and characteristics will be noted during spring surveys. Certain monitoring equipment will be placed in the field indefinitely (i.e. wildlife cameras and bat detectors) allowing potentially uninterrupted observation at their respective locations (Figure 5-1).

5.4 List of Data to be Collected

- Counts (sightings) of the various wildlife species including birds, reptiles, amphibians, and mammals.
- Signs of species (i.e. scat, feathers, burrows, bones, etc.).
- Frequency—the number of transects and/or surveys a particular species is encountered.
- Key habitat features and characteristics suitable to various wildlife.
- Inventory of threatened or endangered species and habitat.

5.4.1 Birds

Bird habitat within the proposed project area consists of primarily piñon-juniper and mixed conifer habitat (Cox 2013). Birds will be censused to generate density data during the breeding bird season (April-August; three separate surveys) and occurrence and abundance data during winter (December-February), stratified by habitat type. The activity status of raptor nests will be observed during the breeding and winter censuses.

5.4.2 Reptiles

Species and counts of reptiles observed during small mammal trapping, stratified by habitat type, will be recorded.

5.4.3 Non-volant Mammals

Big game surveys will yield counts, distribution, and habitat affinity. Winter occurrence (January – February) and reproductive success (August – September) will be obtained to provide a minimal assessment of big game status. Small mammal surveys will yield data on distribution and relative abundance during the fall (August – October) and total small mammal biomass stratified by habitat type.

5.4.4 Volant Mammals (bats)

Bat data to be collected will include characterization of bat habitat and potential associated species use, resident and migratory species composition, the location of significant hibernation and maternity roost sites, if present, and bat use of existing mines and features.

5.5 Methods of Collection

Data will be collected through visual/pedestrian transect surveys to identify nests, burrows, fecal pellets, and other pertinent signs of wildlife. Eight motion-triggered wildlife cameras have been placed throughout the proposed project area to provide constant monitoring of wildlife within each of the four putative habitat types identified by Metric (1991).

5.5.1 Birds

Birds will be censused using a point count method (Hutto et al. 1986) where the observer stays at each point for five minutes and records all bird species either heard or seen while at the point before moving on to the next point. Each point will be approximately 250 – 300 meters apart. Bird counts will be conducted along two meandering transects, one 35-station transect located in the piñon-juniper habitat, and one 8-station transect located in the mixed-conifer upland habitat.

5.5.2 Reptiles

Species and counts of reptiles observed during small mammal trapping, stratified by habitat type, will be recorded.

5.5.3 Non-volant Mammals

Intensive trapping for small mammals will be conducted in August 2013. Two 200m transects will be established in each of the four putative habitat types identified by Metric (1991) with 25 trapping stations along each transect and two Sherman live traps placed at each trapping station. Each trap will be baited with oats and peanut butter, left open continuously during a three-night sampling period, and checked once each morning. This sampling design will yield 300 trap nights for each of the four habitat sites. Small mammals trapped will be identified, weighed, and released. Measurements may be taken if there is identification uncertainty.

Carnivores, large rodents, deer, and other mammals will be observed by non-trapping observational methods (camera arrays, tracks, droppings, live sightings made during other field surveys).

5.5.4 Volant Mammals (bats)

Identifying significant hibernation and maternity roost sites in mines with relatively safe and unrestricted human access (e.g. Candelario mine) is typically accomplished by visually inspecting all shafts, adits, drifts, winzes, and other features for clusters of roosting bats during the appropriate seasons. Since some populations of hibernating bats are known to move to different locations within a given mine early in the hibernating season, or to move to a different mine altogether, visual inspections will be conducted around the middle of the hibernation season. For features that are only accessible to bats, mist-netting or acoustic survey techniques will be used to get an approximation of hibernating or maternity populations. Such surveys are best conducted during late winter or early spring for hibernating colonies, when bats are just beginning to become active. Maternity roosts are usually established sometime around early summer. All internal mine surveys will be conducted by a minimum of two people, with one additional person stationed outside the mine. Locating roosting sites for tree-roosting species can be quite a bit more problematic. However, it is possible to infer the presence of such hibernation sites if non-migratory species are encountered in late fall acoustic or mist-netting surveys. Likewise, the capture of pregnant tree-roosting species in mist nets during late spring or early summer is obviously indicative of the presence of maternity sites. Since tree-roosting sites do not appear to be limited in the Ortiz Mountains, an extensive effort into the identification of such sites might not be warranted.

Outside of the critical hibernating and maternity seasons, bats may also use mines and other subterranean features as day-roosts, or as staging or stopover areas during migration. Such sites can often have significant congregations of bats and may have been utilized for many years. Typically, these day-roost sites might be more exposed than hibernation or maternity sites and might exhibit more micro-environmental fluctuations. For example, a feature-rich area might contain ten day-roost sites but only one hibernation site. Techniques for assessing such sites are quite similar to those presented above for the evaluation of hibernation and maternity roosts, with perhaps more of a dependence on acoustic and mist-netting procedures.

The ACS remote bat detection system is based on the state-of-the-art Binary Acoustic Technology (BAT) AR125 ultrasonic receiver, FR125 recording and control unit, and associated software. The BAT equipment is unique in that it digitally processes and compresses ultrasonic vocalizations and generates waveform audio files (wav). These wav files preserve the entire spectrum of the original call, while eliminating the artificial harmonics, distortions, and background noises associated with all other currently available ultrasonic detection systems. In short, the resultant wav files are the most acoustically accurate representations of bat vocalizations available today. Also, the BAT system does not have a time delay between processing one call and recording the next, as other wav-based systems do. The remaining components for one individual detection system include a mounting structure, solar panel, battery, charge controller, data storage device, weatherproof enclosure, and, when remote data transmission is desired, a modem and antenna. A photograph of a typical ACS long-term acoustic monitoring station is given in Figure 2.

For the current study, two long-term monitoring stations will be installed. One will be set up adjacent to an aboveground stock tank. Since water balance is a key component of bat physiology, over the course of a year such a placement will undoubtedly record every bat species that resides in or passes through the project area. The other will be placed in an opening adjacent to a ponderosa pine and mixed woodland. This placement will be purposely biased towards tree-roosting species.

Erecting a mist net (or specialized harp trap) at the entrance of a mine shaft or adit, or over a nearby water source, is an effective and definitive way to identify the local bat fauna. Mist netting also allows the opportunity to assess the health of bats or to mark them for population or distribution studies. In addition, handling the bats makes it possible to identify gravid females, which would indicate a nearby maternity roost. Mist netting can also be used to validate calls recorded on the acoustic monitoring systems.

For the current study, mist-netting will be performed on two nights during spring, summer, and fall. Each bat caught will be identified, sexed, weighed, measured, marked, and released.

5.6 Parameters to be Analyzed

- Density of observed avian species.
- Bird nest density and distribution.
- Relative abundance and distribution by habitat and season.
- Density and distribution of wildlife indicators (e.g. fecal pellet counts) and occurrences (sightings) of wildlife.
- Acreages and maps of key habitat areas for various wildlife species.
- Threatened and endangered species survey results.

5.7 Maps Showing Proposed Sampling Locations

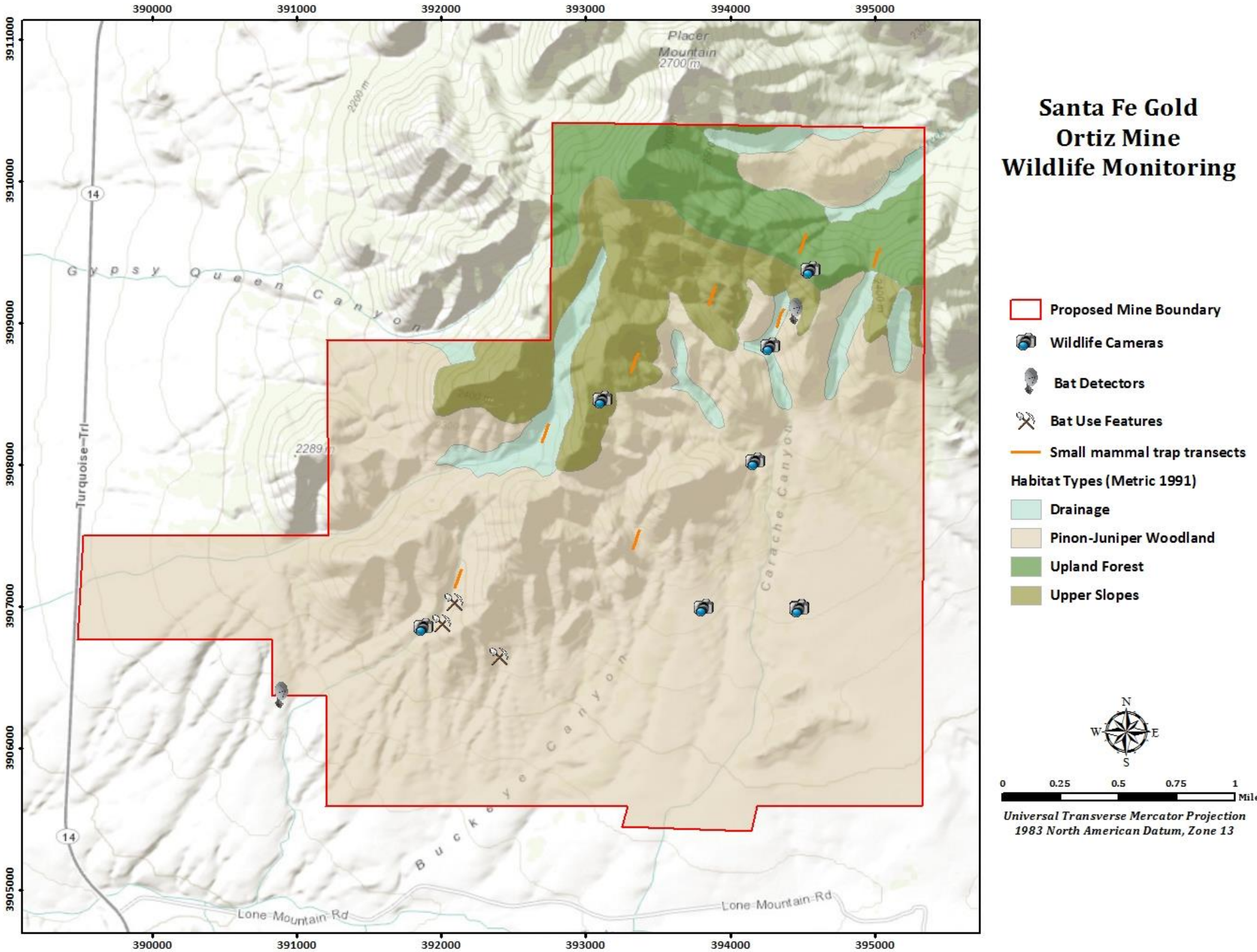


Figure 5-1. Wildlife monitoring

5.8 Laboratory and field Quality Assurance Plans

In addition to being relatively standard methods of ecological sampling prescribed by the NM Department of Game and Fish (NMDGF 2010 and references therein) and accepted by the MMD, the sampling and analysis methods proposed for the Ortiz Mine are described in detail in the associated GL Environmental, Inc. Quality System Administrative Standard Operating Procedures (SOPs), Equipment SOPs, and Field SOPs. These documents establish procedures for quality related activities throughout the company and ensure compliance with regulatory requirements and the GL Environmental, Inc. Quality Policy. The Quality Policy is documented within the Quality Assurance Program Manual and execution of the system is described in the Quality Assurance Implementation Plan (Appendix C).

5.9 Discussion Supporting the Proposed Sampling Plan

This sampling plan will provide an accurate description of wildlife species occurring in the Ortiz Mine permit area. By utilizing a sampling design that involves sampling over several seasons per year and several times during each sampling period, there is less chance for data to become biased toward early or late seasonal species (Holthausen *et al*. 2005). Additionally, a combination of pedestrian surveys and stationary observation equipment should provide robust estimates of wildlife species and habitat use.

6 Topsoil Survey and Sampling

6.1 Introduction and Background

The success of SFG's reclamation program depends in part on the suitability and amount of material salvageable from the areas to be disturbed and capable of supporting vegetation for reclamation activities. SFG will characterize the quantity and quality of topsoil available by:

- Reviewing existing NRCS data for the proposed permit area
- Surveying the proposed permit area to verify and expand on NRCS data
- Performing an order 1 soil survey and laboratory analysis in areas proposed for disturbance as well as any potential borrow areas

Approximately 753 acres within the 4,702-acre proposed project boundary are prohibitively steep, precluding access by equipment for sampling. Previous mapping efforts (USDA NRCS 2008) indicate that the remaining 3,949 acres comprise thirteen soil types (Figure 6-1). Two soil types, the Wandum-Alchonzo-Rubble land complex and the Pedregal very cobbly loam, make up 2,908 acres or 74.3% of the proposed permit area (Table 6-1):

Table 6-1. Proposed soil map unit sampling within proposed permit area

Map Unit	Map Unit Name	Acres	Proportion	Samples
116	Arents-Urban land-Orthents complex, 1 to 60 percent slopes	0.2	0.0%	0
500	Sedillo very gravelly loam, 2 to 6 percent slopes	39.8	1.0%	1
501	Truehill extremely gravelly loam, 25 to 55 percent slopes	117.0	3.0%	2
510	Cerrillos-Sedillo complex, 1 to 5 percent slopes	230.2	5.8%	3

Map Unit	Map Unit Name	Acres	Proportion	Samples
511	Wandurn-Alchonzo-Rubble land complex, 35 to 90 percent slopes	1536.5	38.9%	4
512	Cochiti extremely cobbly loam, 15 to 35 percent slopes	214.6	5.4%	2
513	Pedregal very cobbly loam, 8 to 15 percent slopes	1397.4	35.4%	6
514	Pegasus extremely cobbly loam, 20 to 50 percent slopes	89.3	2.3%	1
515	Pastorius very cobbly loam, 3 to 5 percent slopes	84.9	2.2%	1
521	Devargas-Riovista-Riverwash complex, 0 to 5 percent slopes, flooded	189.9	4.8%	0
527	Musofare-Asparas complex, 20 to 50 percent slopes	7.8	0.2%	0
534	Oelop-Charalito complex, 1 to 3 percent slopes	30.1	0.8%	0
550	Pits, mine	12.2	0.3%	0
	Grand Total	3949.8	100.0%	20

6.2 Sampling Objectives

The first objective of the topsoil survey is to verify and expand upon previous mapping efforts (USDA NRCS 2008) to provide a more detailed map of soil units. After soil units are defined within the proposed permit boundary, SFG's second objective is to sample each unit that can be practicably salvaged to provide an estimate of soil quality within that unit. Because soils in the area may be sulfitic and result in acid drainage when exposed to precipitation, laboratory analysis of the soil is proposed to determine potential for soil disturbance to create acid drainage, cause degradation of surface water and/or ground water, or cause a hindrance to reclamation.

The final objective of the topsoil survey is to combine the results of mapping and sampling to sufficiently estimate the volume of on-site soils.

6.3 Sampling Frequency

In accordance with 19.10.6.602 of the New Mexico Administrative Code (NMAC), there will be one sampling event for topsoil characterization during the 12-month baseline data collection period.

6.4 List of Data to be Collected

- Actual surface distribution of map units (relative to previous mapping efforts)
- Soil properties, including color, presence of calcium carbonates, salt accumulation, volume of coarse fragments, and depth to bedrock or rocky layer at 20 sampling location (Table 6-1)
- Analytical parameters for sub-samples will include particle size distribution, paste pH, electrical conductivity, saturation percentage, sodium adsorption ratio (SAR), selenium, boron, acid/base accounting, rock fragment percentage, nitrate-nitrite, phosphorus, potassium, iron, magnesium, manganese, copper, cadmium, lead, mercury, molybdenum, nickel, and arsenic.

6.5 Methods of Collection

A pedestrian soil survey will be conducted within the proposed permit area to delineate topsoil. First order soil surveys have delineations of 1 hectare (2.5 acres) or less, depending on scale; typically show phases of soil series and miscellaneous areas as components of map units; and typically display results at a scale of 1:15,840 or larger (Soil Survey Division Staff, 1993). Survey transects will be concentrated in areas defined as map unit boundaries of the proposed permit area. While walking along each transect, the boundaries for topsoil will be delineated by making visual observations of surface soils and confirming those observations with hand-auger holes. Topography, vegetative cover, slope and aspect will all be used to guide the decisions. Boundaries recorded in the GPS receiver will be uploaded and imported into an ESRI geographic information system (GIS) as a shapefile.

A more refined (Order 1) estimate of soil resources, supported by sampling, is planned for areas with a high potential for use in reclamation (Table 6-1, Figure 6-1). Soil profiles at each sampling location will be exposed using a hand auger, shovel, backhoe, or other means necessary. Excavation methodology will depend on the depth to bedrock, hardened surface or mineral soil is reached. A total of 20 sampling locations are proposed. Based on the high proportion of gravel and cobble that is predicted to occur across much of the permit area, only 5 to 8 samples are likely to be sampled by hand; 12 to 15 will likely require a backhoe to assess soils.

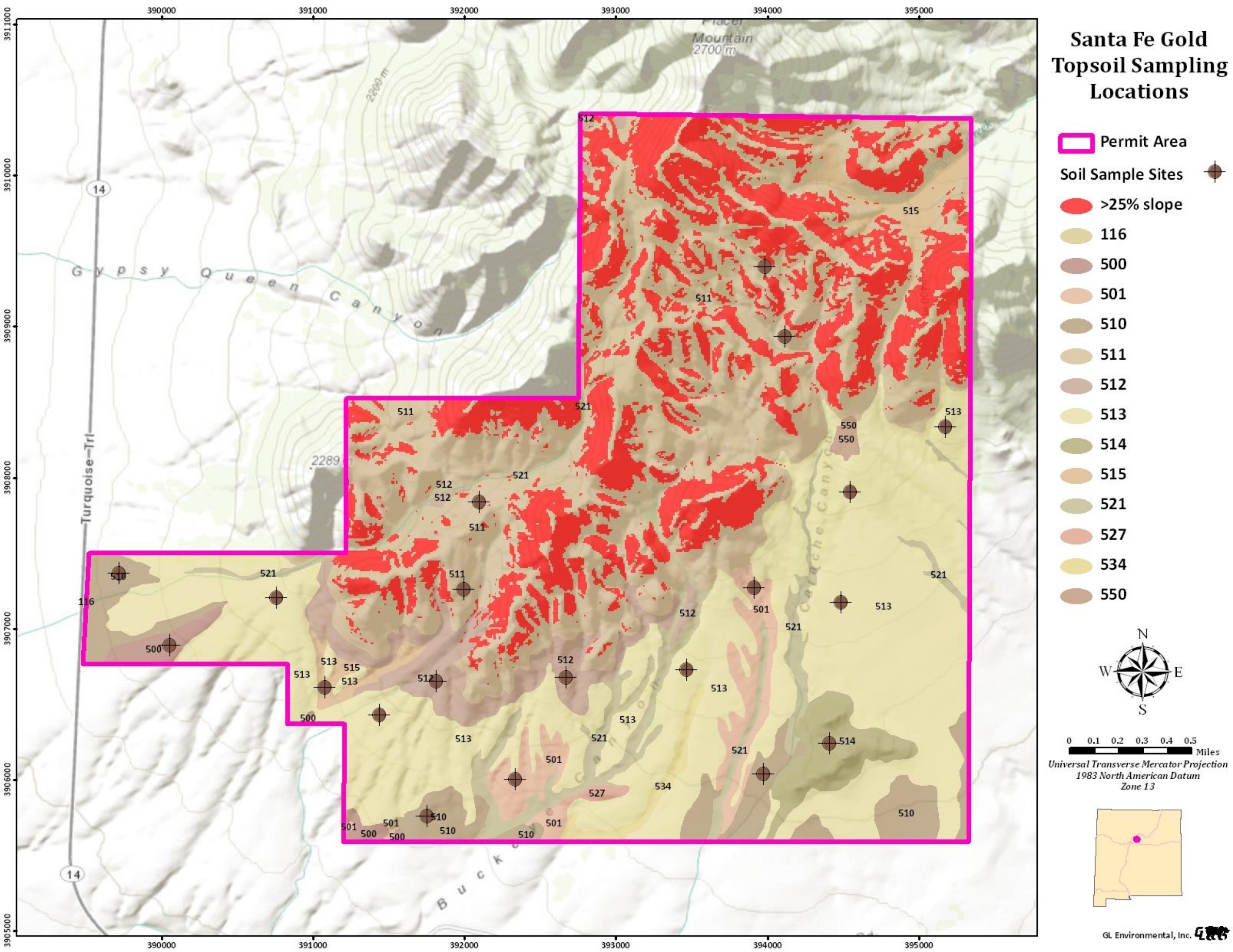
Soil texture will be estimated visually at 6-inch intervals within the top 2 feet (ft). Below 2 ft, texture will be estimated at 1-ft intervals. Soil properties, such as color, presence of calcium carbonates, salt accumulation, volume of coarse fragments, and depth to bedrock or rocky layer, will also be noted. At each sample location, a soil subsample will be collected from each discreet soil type in the topsoil and sent to a laboratory for analysis. The actual location of the subsample will be recorded with a GPS. Sample containers will be sealed, labeled, and logged according to appropriate chain-of-custody procedures. Samples requiring immediate laboratory analysis will be placed in shipping containers (coolers), maintained at the appropriate temperature and shipped to the laboratory for analysis within 24 hours of sample collection.

6.6 Parameters to be Analyzed

Analysis parameters will include soil type, soil thicknesses, paste pH, electrical conductivity, saturation percentage, particle size distribution, sodium adsorption ratio (SAR), selenium, boron, acid/base potential, rock fragment percentage, nitrate-nitrite, phosphorus, potassium, iron, magnesium, manganese, copper, cadmium, lead, mercury, molybdenum, nickel, and arsenic.

6.7 Maps Showing Proposed Sampling Locations

Figure 6-1. Soil map of proposed permit area



6.8 Laboratory and field Quality Assurance Plans

The sampling and analysis methods proposed for the Ortiz Mine will be conducted in accordance with the Natural Resource Conservation Service Soil Survey Manual (Soil Service Division Staff, 1993) in conjunction with the associated GL Environmental, Inc. Quality System Administrative Standard Operating Procedures (SOPs), Equipment SOPs, and Field SOPs. These documents establish procedures for quality related activities throughout the company and ensure compliance with regulatory requirements and the GL Environmental, Inc. Quality Policy. The Quality Policy is documented within the Quality Assurance Program Manual and execution of the system is described in the Quality Assurance Implementation Plan (Appendix C). Convenience

Additionally, any vendors that provide analytical data are procured through the use of a Quality Assurance Purchase Order (PO). This document requires the vendor to adhere to, at a minimum, GL's quality assurance program as well as any specifications required by the client. GL requires that any contracted analytical laboratory hold current National Environmental Laboratory Accreditation Program (NELAP) or equivalent accreditation.

6.9 Discussion Supporting the Proposed Sampling Plan

The proposed data collection will allow the characterization and establishment of baseline topsoil conditions across the proposed mine boundary in advance of mining.

- Pedestrian surveys will provide ground-truthing of previous soil mapping efforts and a gross estimate of resources across the proposed permit area.
- Order 1 sampling at the proposed locations will provide a more robust estimate of soil resources in areas with a high potential for use in reclamation. These areas are characterized as having high potential because either they occur within areas of proposed disturbance or because they occur in areas predicted to have soils suitable for use in revegetation or liner substrates.
- The proposed analytical suite will determine potential for soil disturbance to create acid drainage, cause degradation of surface water and/or ground water, or cause a hindrance to reclamation.

7 Mineralogy and Geology

7.1 Introduction and Background

Most of the following information has been obtained from papers prepared by Stephen R. Maynard *et al*. and many individuals who worked for the LAC Minerals-Pegasus Joint Venture during the 1980's and early 1990's. Additional information has been acquired from David Coles' 1990 thesis paper *Alteration and Mineralization of the Carache Canyon Gold Prospect, Santa Fe County, New Mexico*.

The Ortiz Mountains are part of the San Pedro-Ortiz porphyry belt, a north-northeast trending group of Oligocene-age stocks, laccoliths, sills and dikes that intrude the Precambrian basement complex and the overlying late Paleozoic- to Tertiary-age sedimentary rocks. This porphyry belt lies near the eastern margin of the Rio Grande Rift and is a part of a much larger north-south trending belt of gold-bearing, alkalic, intrusive centers extending from west Texas to Montana along the western margin of the Great Plains. Volcanism, contemporaneous with intrusions in the Ortiz Mountains and nearby Cerrillos Hills, resulted in deposition of the Miocene-age Espinaso volcanics.

In the Ortiz Mountains, the porphyry belt is cut by the northeast-trending Tijeras-Cañoncito fault system, one of numerous fault splays off the Rio Grande Rift. The Rift developed during a period of continental extensional stress in Cenozoic time. The Tijeras-Cañoncito fault system, however, shows a history of recurrent movement ranging from the Precambrian to the Holocene and it has been suggested that this fault system provided basement control for the intrusions and related base- and precious-metal mineralization in the area.

7.2 Geology of the Ortiz Mine Site

The Ortiz Mountains and the proposed permit area are dominated by a group of mid-Tertiary calc-alkaline and alkaline intrusive stocks, laccoliths, sills and dikes intruding a Pennsylvanian to Eocene-age suite of sedimentary rocks composed mostly of shales and sandstones with a few thin limestone beds.

7.2.1 Stratigraphy

7.2.1.1 Sedimentary Units

The principal sedimentary rocks exposed in the Ortiz Mountains are the Upper Cretaceous-age Mancos Shale and Mesaverde Group consisting primarily of interbedded shales and sandstones. The total Mancos section is estimated to be about 2500 to 3000 feet thick and contains two identifiable, impure limestone members, the Juana Lopez (3-6 feet thick) and the Greenhorn (50-60 feet thick). The Mancos Shale is exposed mostly on the western and southern flanks of the mountains. The Mesaverde Group may be as much as 1800 feet thick and contains several thin coal beds, typically 2 to 5 feet thick. The Mesaverde is mostly exposed on the northern and eastern flanks of the mountains. Although both formations are locally disrupted by intrusive rocks, the general stratigraphic trend is northerly with a 10º easterly dip.

The only significant limestone units are the Pennsylvanian-age Madera Formation which is several hundred feet thick and the Permian San Andreas limestone which is about 20 feet thick. Neither outcrop in the Ortiz Mountains. The Madera and underlying Sandia sandstone lie unconformably on Precambrian-age metamorphic schists and quartzites intruded by stringers of pink granite and are only exposed along the northern slope of the uplifted San Pedro Mountain block.

Summaries of the sedimentary units, which crop out in the Ortiz Mountains, are presented below from oldest to youngest. A Geologic Map of the Ortiz Mine Grant, Santa Fe County New Mexico has been included as Figure 7.1. Stratigraphic cross-sections of the Ortiz Mine Grant are included in Figure 7.2.

<u>Chinle Formation (TRc) (Upper Triassic)</u>

The Chinle Formation crops out in the southwestern part of the Ortiz Mine Grant and is best exposed near the access road to Carache Canyon. This unit consists of reddish brown shale and siltstone with interbeds of thin-bedded sandstone. Bachman (1975) estimated a thickness of 150m (500 ft.) for this unit.

<u>Entrada Sandstone (Je) (Upper Jurassic)</u>

The Entrada Sandstone overlies the Chinle and crops out in the southwestern Ortiz Mountains. It is fine to medium-grained, buff to tan, massive sandstone that was measured by Peterson (1958) at 45m (150 ft.) thick in this area.

<u>Todilto Formation (Jt) (Upper Jurassic)</u>

Like the Entrada, the Todilto crops out in the southwestern Ortiz Mountains. This unit overlies the Entrada and consists of lamellar, dark gray, shaly limestone, measuring 2 meters (7 ft.) thick, and overlying gypsum of thickness ranging from 0 to 20 meters (0 – 66 ft) thick (Peterson, 1958).

Morrison Formation (Jm) (Upper Jurassic)

The Morrison Formation overlies the Todilto and crops out along the southwestern edge of the Ortiz Mountains. Peterson (1958) measured a thickness of 147m (483 ft.) of massive quartzose sandstone and shale. Intrusion of a sill between the Morrison shales and overlying Dakota Sandstone has locally resulted in metamorphism of the shale to pale pink and green hornfels.

Dakota Sandstone (Kd) (Cretaceous)

This unit overlies the Morrison Formation and crops out at the western edge of the Ortiz Mountains. It consists of well bedded, yellowish gray, quartzose sandstone, measured by Bachman (1975) to range from 28 to 45m (90 to 150 ft.) thick.

Mancos Shale (Km) (Upper Cretaceous)

The Mancos Shale overlies the Dakota Sandstone, and crops out in the western Ortiz Mountains and in the vicinity of Lone Mountain. This unit is subdivided into five members at Carache Canyon. The lowermost member of the Mancos is the Graneros Shale which consists of 55m (180 ft.) of thin bedded, medium gray marine shale (Bachman, 1975). Overlying the Graneros Shale Member is the Greenhorn Limestone Member, which consists of interbedded, medium gray, argillaceous limestone and calcareous shale. The Greenhorn is 18m (60 ft.) thick at Carache Canyon. The Carlile Shale Member overlies the Greenhorn Limestone Member and consists of medium gray thin bedded shale with a measured thickness of 220m (723 ft.). Overlying the Carlile Shale Member but included with the Carlile in the Ortiz Mountains is the Juana Lopez Member. This member consists of fetid limestone that is 1.8m (6 ft.) thick. Overlying the Juana Lopez Member is the Niobrara Member which has an average measured thickness of 94m (307 ft.) in drill core from Carache Canyon. This unit consists of interbedded black shales, sandy shale and minor sandstone. The Hosta-Dalton Sandstone overlies the Niobrara Member and crops out west of Carache Canyon. This sandstone is interpreted by Sterns (1953c) as an intertongue of the Mesaverde Group (Cano Member of the Mesaverde). Due to its highly variable thickness, and possible absence from some drill holes, the Hosta-Dalton Sandstone is included in the Upper Mancos Member at Carache Canyon. The Upper Mancos consists of interbedded black shales, siltstones and minor sandstones similar to those of the Niobrara Member. In drill core from Carache Canyon the Upper Mancos Member averages 137m (450 ft.) thick.

Mesaverde Group (Kmv) (Upper Cretaceous)

The Mesaverde Group has been subdivided into four members at Carache Canyon by LAC Minerals' company geologists. The basal unit is a 30m (100 ft.) thick unit of massive, light-gray, sandstone (Point Lookout Sandstone). This unit serves as an important stratigraphic marker in the Ortiz Mountains. Overlying the Point Lookout is the 100m (328 ft.) thick Lower Menefee Member which consists of interbedded shale, siltstone, minor sandstone and coal. The Harmon Sandstone, a 27m (90 ft.) thick, light gray, fine grained sandstone unit separates the Lower Menefee from the Upper Menefee Member which is the highest stratigraphic unit in the Mesaverde Group. The Upper Menefee consists of at least 100m (330 ft.) of interbedded shale, siltstone and minor sandstone. Members of the Mesaverde Group crop out in the northern Ortiz Mountains, underlie the majority of Carache Canyon, and crop out to the west of Carache Canyon.

<u>Diamond Tail Formation (Tdt) (Paleocene)</u>

The Diamond Tail Formation unconformably overlies the Mesaverde Group (Sterns, 1943, 1953b), and crops out within the Ortiz graben and to the north of the Ortiz Mountains. The Diamond Tail Formation is composed of coarse sandstone and is approximately 300 m (1,000 ft) thick.

<u>Galisteo Formation (Tg) (Oligocene and Eocene)</u>

The Galisteo Formation overlies the Diamond Tail Formation, and crops out within the northeastern quadrant of the Ortiz Mountains. The Galisteo Formation consists of variegated shale, siltstone, sandstone and minor conglomerate (Sterns, 1953c).

<u>Espinaso Formation (Te) (Oligocene)</u>

The Espinaso Formation crops out in the northeastern and far western portions of the Ortiz Mine Grant. It consists of gray to light-gray, volcaniclastic sandstone and conglomerates that are locally interbedded with debris-flow deposits, volcanic ash, and latite flows (Kautz et al., 1981). The Espinaso sediments and volcanics were derived from the Cerillos and Ortiz eruptive centers (Sterns, 1953a; Kautz et al., 1981).

<u>Tuerto Gravels, Colluvium and Alluvium (QTt) (Quaternary)</u>

These units consist of unconsolidated gravels and talus that are a mixture of igneous, sedimentary and hornfel sedimentary rocks. They represent the coarse products eroded from the Ortiz and San Pedro Mountains (Bachman, 1975).

7.2.1.2 Igneous Units

The intrusive rocks consist primarily of an older suite (34 ma) of calc-alkaline rocks comprising andesite porphyry sills, laccoliths and dikes; and a granodiorite stock known as the Candelaria stock which is regarded as being the youngest of the suite. A younger suite (30-26 ma) of alkaline rocks comprised of a large nepheline-bearing, augite-monzonite stock, a latite-porphyry hypabyssal plug, the Ortiz diatreme (a vent breccia) and radial trachytic-latite dikes form the core of the Ortiz Mountains. Most of the gold mineralization is related to this younger group of alkaline igneous rocks.

Early Intrusives

<u>Andesite Porphyry (Tap)</u>
In the western portion of the Ortiz Mountains andesite forms laccoliths and plugs (Peterson, 1958). Away from these intrusive centers, including the Carache Canyon area, andesite occurs as sills that intrude Cretaceous and Tertiary sedimentary rocks (Peterson, 1958; McRae, 1958; Bachman, 1975; Maynard et al., 1989). The andesite porphyry ranges from greenish gray to grayish green on fresh surfaces. Weathering produces surfaces that are olive drab to brownish green. Fractures in weathered rock locally contain coatings of iron and manganese oxides.

Phenocrysts make up 46% of the andesite on average with plagioclase as the dominant crystal. Hornblende phenocrysts are euhedral, range from fine to medium grained, and are black in fresh specimens. Quartz is the least abundant phenocryst, and occurs as and occurs as fine to medium grained, clear, highly resorbed crystals.

The microcrystalline groundmass makes up approximately 54% of the rock, with groundmass plagioclase averaging 29%, orthoclase 18% and quartz 7%. Trace minerals include apatite and sphene which locally make up more than 1% of the rock. Allanite, zircon and rutile occur as accessory minerals that make up less than 1% of the rock.

Quartz-Hornblende Monzodiorite (Tqmd)

Quartz-hornblende monzodiorite (Candelaria Stock) crops out at Candelaria Mountain. This forms steep slopes and cliffs. The rock generally is medium to light gray, and hornblende crystals impart a black speckled appearance on fresh surfaces. Weathered surfaces are usually chalky gray to tannish brown, depending on the intensity of iron oxide staining.

Plagioclase, the dominant constituent (51%), occurs as subhedral to euhedral crystals. Orthoclase (19%), occurs as anhedral crystals and is interstitial to the plagioclase and ferromagnesium minerals. Hornblende constitutes 15% of the rock, is subhedral, and exhibits minor alteration to biotite, chlorite, epidote and quartz. Quartz (13%) occurs as anhedral crystals, interstitial to plagioclase and hornblende.

Accessory minerals include magnetite, apatite, sphene and rutile. Magnetite locally constitutes from 1 to 2% of the rock where it occurs as subhedral crystals. Other accessories make up less than 1% of the rock and are typically euhedral.

Late Intrusives

Augite Monzonite (Tam)

Augite monzonite forms the high peaks that define the core of the Ortiz Mountains. On fresh surfaces the rock ranges from light gray to deep gray or black. Locally, potassium feldspar imparts a pinkish tint to the rock. Weathered surfaces appear chalky to grayish white to tannish brown depending on the presence and thickness of iron-oxide stains.

Plagioclase is usually the dominant phase in the augite monzonite, making up 43% of the rock and occurs as subhedral crystals. Orthoclase (37%) is found in subequal amounts to plagioclase and occurs as anhedral to subhedral crystals that locally enclose plagioclase, augite and hornblende. The augite monzonite contains between two and ten weight percent normative nepheline. Augite (8%) and hornblende (8%) are present in subequal amounts, with augite usually dominating.

Biotite occurs as a trace mineral that, like hornblende, grew as a replacement of augite. Magnetite is the most abundant accessory mineral making up 3% of the rock on average and ranging from 2 to 5%. Apatite, sphene, zircon, rutile and allanite occur as accessory minerals that make up less than 1% of the rock.

Latite Porphry Stocks and Latite Dikes (Tlp)

A latite-porphyry hypabyssal plug, the Ortiz diatreme (a vent breccia) and radial trachytic-latite dikes form the core of the Ortiz Mountains. The rock is light gray to tan with sub- to euhedral alkali feldspar phenocrysts. Hornblende and lesser aegirine-augite range from 1 mm to microscopic. The groundmass consists of fine grained to aphantic alkali feldspar. Apatite (~1%) occurs as an accessory mineral. Latite porphyry stocks are closely associated with base and precious-metal mineralization in the Ortiz Mountains.

7.2.2 Structure

Structurally, the Ortiz Mountains are dominated by the Tijeras-Cañoncito fault system (TCFS) which strikes northeasterly across the southern and eastern parts of the range (Figures 7-1 and 7-2). The high-angle bounding faults have numerous splays, some of which cut diagonally across the fault zone resulting in the formation of horst and graben blocks (Figure 7.2). The Ortiz graben, the Ortiz diatreme and the Carache Canyon breccia pipe appear to be structurally controlled by the TCFS.

The Ortiz graben contains several tilted blocks of the Menefee Formation (part of the Mesaverde Group) and the unconformable overlying Paleocene-age Diamond Tail Formation consisting of sandstone and conglomerate. Vertical stratigraphic displacement of 2000 to 4000 feet is estimated on the graben's bounding faults. Left-lateral stratigraphic separation on the Dakota Sandstone Formation measures about 3 miles across the TCFS. The northern side of the TCFS is down thrown with respect to the southern side. The amount of displacement is unknown.

The Ortiz diatreme, or vent breccia, erupted on the northwestern margin of the northwestern graben-bounding fault of the TCFS. The diatreme has a crude elliptical shape, roughly 6900 by 3900 feet in plan view, and is composed principally of tuff, lithic tuff, and volcanic breccia. The lithic clasts in the tuff are mostly augite-monzonite, latite-andesite porphyry, and Cretaceous- to Paleocene-age sedimentary rocks.

Breccia pipes occur in two main zones along the southeastern and northwestern margins of the diatreme. The northwestern margin is a fault contact of the vent breccia with the augite-monzonite stock and the southeastern margin is an intrusive contact characterized by intense brecciation of the wall rocks as at the Cunningham Hill and Benton mines.

Another breccia pipe, the Carache Canyon pipe, lies about 1.5 miles southwest of the Ortiz diatreme and 400 feet northwest of the Ortiz graben. This pipe measures 1800 by 1000 feet in plan view, is elongate in a northeasterly direction, and plunges 70º to the southwest.

It has been hypothesized that deep-seated fractures parallel to the TCFS probably served as conduits for vapor release and as a zone of weakness for brecciation and subsequent collapse, resulting in the development of the Carache Canyon breccia pipe. Concurrently, magmatic withdrawal during eruption of the nearby Ortiz diatreme may have allowed room for the collapse of the pipe.

7.2.3 Mineral Deposits

A number of mineral deposits in a variety of geologic settings occur in the Ortiz Mountains and within the Santa Fe Gold lease. Gold is the primary mineral of interest with some byproduct copper occurring in the Lukas Canyon deposit. Most of the deposits occur along or near strands of the Tijeras-Cañoncito fault system. The two deposits of principal interest are the Carache Canyon breccia pipe (gold) and the Lukas Canyon skarn (gold-copper). Other deposits are significant for future exploration and potential development. Most of the following information has been excerpted from work done by LAC Minerals and the succeeding Joint Venture with Pegasus Gold in the period 1983 to 1994. The work has been well summarized by Maynard et al. (1990, 1991)

Carache Canyon Deposit

The Carache Canyon gold deposit is associated with a collapse-breccia pipe. In plan, the pipe is tear-drop shaped, measuring 1800 by 1000 feet on surface and plunging 70º to the southwest. The pipe has a known down-dip extent of more than 3200 feet. The pipe is characterized by collapsed beds of shale and sandstone and latite-andesite porphyry sills. Relict stratigraphy, largely defined by the Point Lookout Sandstone of the Mesaverde Group, indicates as much as 800 to 1000 feet of collapse. The breccia is typically clast supported and locally contains as much as 10% dark-colored, rock-flower matrix.

Secondary fracturing of the Carache pipe resulted in randomly oriented open-space fractures that are concentrated in an annular zone around the southwestern margin of the pipe. This fracture zone occurs both inside and outside of the pipe margin. Fractures are best developed in the latite-andesite sills and the Point Lookout Sandstone, whereas the shales of the Mancos and Menefee Formations contain few open-space fractures. As a result, mineralization exterior to the pipe is concentrated in a series of stacked, tabular bodies separated by intervals of relatively barren shale whereas inside the pipe the mineralization is randomly distributed.

Strong oxidation of the Carache Canyon deposit extends to depths of 200 feet. Unoxidized mineralization in the deposit is in the form of coarse gold in open-space fractures with pyrite, pyrrhotite, chalcopyrite, sphalerite, galena, arsenopyrite, calcite, and adularia (orthoclase feldspar). Gold appears to have been deposited late in the paragenitic sequence and seems to be closely related temporally to the intrusion of trachytic latite dikes. Some dikes are fractured and mineralized and others are unfractured and cut mineralization.

Significant mineralization occurs primarily in the sills and in intervals frequently exceeding 50 feet and occasionally up to 100 feet thick.

An open-pittable Measured and Indicated Resource has been estimated at 12.9 million tons grading 0.046 oz Au per ton for 595,000 contained ounces of gold. That Resource estimate has been determined by using a gold price of $1500 per ounce and applying appropriate economic and recovery factors to the model. An additional Inferred Resource of 1.8 million tons grading 0.026 oz Au per ton for 47,500 ounces of gold is contained within the proposed pit outline.

Lukas Canyon Deposit

The Lukas Canyon deposit is a skarn-hosted, copper-gold deposit developed in the 50-foot-thick Greenhorn Limestone member of the Mancos Formation. A garnet-pyroxene skarn was probably developed at the time of the emplacement of the nearby Candelaria granodiorite stock. The copper and gold mineralization postdate the primary skarn and are probably related to a late stage of retrograde alteration which resulted in the present chlorite-actinolite-epidote skarn.

The deposit lies at surface on the dip slope of the Greenhorn Limestone. The bed dips at 15º to 20º easterly in the southern parts and is relatively flat in the northern area. Oxidation is intense, resulting in a complex suite of copper and iron oxides. Relict sulfides of pyrite and chalcopyrite are locally present. The gold mineralization is generally finely disseminated in the skarn. Where the skarn bed dips beneath overlying strata in the southeastern parts, pyrite in the order of 1 to 2 percent occurs in both the skarn and the overlying shale. Within the skarn, up to several percent of mixed pyrite and chalcopyrite with good gold values occurs locally. The extent of sulfide mineralization is poorly defined but is a very small part of the deposit.

Typical mineralized intervals range from 10 to 60 feet thick (Figure 3)

An open-pittable Measured and Indicated Resource totaling 14.3 million tons grading 0.026 oz Au per ton and 0.142% Cu has been estimated using a gold price of $1500 per ounce and a copper price of $3.50 per pound. This Resource contains 378,000 ounces of gold and 40.6 million pounds of copper. An additional Inferred Resource of 1.1 million tons grading 0.014 oz Au per ton and 0.122% Cu for 15,000 ounces of gold and 2.7 million pounds of copper is contained within a proposed pit outline. These Resources have been defined by applying appropriate economic and metallurgical recovery factors.

7.3 Sampling Objectives

Mining is an industrial activity that exposes and redistributes bedrock and overburden. The new depositional environment of the disturbed material may result in the exposure of bedrock and overburden to oxygen and water. Significant changes in mineral stability can result when certain materials are brought into contact with atmospheric conditions (water and oxygen). The primary objective of the Ortiz Mine geologic sampling and analysis plan will be to determine if the substrata that would be disturbed during the proposed mining activity and/or tailings material generated during milling operations possess chemical attributes that are likely to create acid rock drainage (ARD) and metal leaching (ML) that may degrade surface water and/or groundwater, or hinder reclamation. The characterization of geologic units and tailings material will be used in the development of a mine plan that will manage materials in a manner that is protective of the environment and complies with applicable regulations.

In order to adequately characterize materials that will potentially be disturbed by mining operations, a sufficient spatial and vertical distribution of surface and core samples will be collected and analyzed. Samples of tails will be collected during metallurgical test work or from a pilot plant. The proposed analysis will allow for interpretation of potential ARD generation, neutralization, ML and facilitate the identification of samples for which kinetic testwork is required.

Analytical results from samples of geologic units that may be disturbed by mining operations will be used to create management units with similar compositions and characteristics. Examples of management units that may be present within the proposed mining area include:

- **Potentially Acid Forming (PAF)** – PAF material can generate AMD if not managed properly. Lithological units with such potential acidity can release acid, salts such as sulphate, and metals/metalloids.
- **Non Acid Forming (NAF) -** NAF Materials can be considered as a potential resource for the management of AMD as long as the potential for these rock types to leach salts and metals is low. NAF material is generally good for use on outer waste rock dump faces.
- **Acid Consuming (AC) -** AC waste may be used to mix with, isolate or encapsulate AF waste. This material may generate alkaline leachate.

- **Uncertain (U) -** Material is given a U classification when test results are inconclusive. Further testing is required to refine the classification of this material.

The volume of material from each management unit present will be calculated and used in the Mine Plan design to ensure proper storage and disposal of materials. The mine plan will also incorporate procedures that mitigate observed ARD characteristics of ore and waste rock during handling and temporary stockpiling. Metallurgical and ARD testwork will be integrated to ensure the mill operation will not only optimize metallurgical performance, but also minimize potential ARD.

7.4 Sampling Frequency

Core recovered from drill holes at the proposed mine area during exploration efforts conducted by Pegasus Gold and LAC Minerals in the 1989-1991 timeframe along with surface samples collected during the summer and fall of 2013 will be the primary material used to characterize geologic units that may be disturbed during mining operations at the Carache Canyon pit. If existing cores and surface samples are insufficient to fully characterize the geologic units, further characterization will be employed by collecting additional samples from existing cores, additional surface sampling, sample collection during future exploration and sample collection during drilling prior to blasting. If necessary, additional sampling would be conducted on tailings material produced from a pilot plant. Additional proposed sample locations and collection methodologies would be provided to NM MMD for approval in the SAP Baseline Data Report.

7.5 List of Data to be Collected

Data to be collected includes a characterization of geologic units that will be disturbed or exposed by mining activities and materials that will be generated during the milling process. Targets for characterization include: 1. Wasterock/overburden; 2. Pit floors and walls; 3. Ore material; and 4. Tailings material. Samples will be analyzed to identify the minerals present and their potential to generate or neutralize acid. Materials will also be analyzed for metals and trace elements and the potential for leaching of metals and other analytes of concern when exposed to predicted depositional conditions.

Sections of existing core samples have been selected for analysis that are representative of geologic units present in and around the Carache Canyon deposit. A total of 10 cores from boreholes completed in the deposit area are available for sample collection. A total of 31 samples will be collected from these cores. A map depicting borehole locations and cross sections displaying core locations and proposed sample intervals has been included in Section 7.6 Methods of Collection.

Acid base accounting, net acid generation, meteoric water mobility procedures, multi-element scans, and if necessary, kinetic testing and petrographic analysis will be performed on samples from affected geologic units. A complete list of proposed analysis is identified in Section 7.7 Parameters to be Analyzed. A review of the analytical results will determine if the sample distribution is sufficient to characterize mineralogical variations within each of the geologic units present due to a potential range of alteration types and alteration intensity. If samples do not adequately characterize variations within the proposed disturbance areas, further sampling will be proposed.

Results from analyses will be used to classify materials into management units and determine where the units occur. These data will be used to calculate the volume of each material category using block models or other appropriate methods. Mine design and operation procedures will accommodate predicted volumes of management units to mitigate environmental impacts.

7.6 Methods of Collection

The Carache Canyon pit floor, walls, and waste rock will be assessed for potential ARD generation and ML by analyzing samples of existing core and surface sampling. During exploration by Pegasus and LAC Minerals, over 850 drill holes were completed to delineate the extent of the Carache Canyon and Lukas Canyon ore bodies. Approximately 7,500 feet of core from 10 holes completed in the Carache Canyon deposit remain in storage. Some of the cores may have been split but are otherwise still intact. The cores have been kept in dry storage since collection in order to preserve the rock and mineral characteristics and ensure the core is representative of the geologic units from which they were obtained.

Sample intervals from cores will be collected from distinct formations or formation members that are expected to be wasterock or make up pit floors and walls. Substantially thick units, such as the lower Menefee formation, may be broken into several sample intervals if they are divided by intrusive andesite sills. Samples will be composited over the identified sample intervals. The locations of the boreholes from which the core was obtained are displayed in figure 7-3, Carache Canyon Core Location Map. Sample intervals from selected cores have been included in cross sections in Figures 7-4 through 7-6, Carache Canyon Pit Cross Sections with Core and Sample Locations.

Table 7-1. Carache Canyon Samples

Core ID	OC54	OC26	OC96	OC36	OC59	Surface
Harmon Sandstone	SFG-C13			SFG-C36		
Menefee Shale - above Harmon Sandstone						SFG-C52
Menefee Shale - above Tap sill #1	SFG-C14					
Menefee Shale - above Tap sill #2A	SFG-C15				SFG-C43	
Menefee Shale - between Tap sill #2A and #2B	SFG-C16	SFG-C22			SFG-C45	
Menefee Shale - between Tap sill #2B and #3	SFG-C17	SFG-C24			SFG-C47	
Andesite porphyry - sill #2A			SFG-C30		SFG-C44	
Andesite porphyry - sill #2B		SFG-C23			SFG-C46	
Andesite porphyry - sill #3		SFG-C25	SFG-C32			
Andesite porphyry - sill #4	SFG-C20				SFG-C49	
Andesite porphyry - sill #3 (breccia)			SFG-C34			
Andesite porphyry - sill #4 (breccia)				SFG-C41		
Point Lookout Sandstone	SFG-C18	SFG-C26			SFG-C48	
Mancos Shale - between Kpl and Tap sill #4	SFG-C19	SFG-C27				
Mancos Shale - (breccia)				SFG-C51		
Mancos Shale - below Tap sill #4	SFG-C21	SFG-C28			SFG-C50	

Spatial distribution of the existing core and proposed surface sample locations is sufficient to intercept each of the geologic units that will be disturbed at the Carache pit. The amount of sampling effort specified for each geologic unit is roughly proportional to the quantity of the material present in the proposed pit outline. The geologic units that will be disturbed and their relative percent contribution to the waste rock generated at the Carache pit are listed in Table 7-3. This information has been provided by the Independent Mining

Consultants, Inc. based on drill hole interpretations and block modeling performed by Pegasus Gold and LAC Minerals.

Table 7-2. Wasterock Composition by Material Type

Carache Canyon Pit	
Sill 1 (Andesite Porphry)	1.18%
Sill 2 (Andesite Porphry)	8.37%
Sill 3 (Andesite Porphry)	2.86%
Sill 4 (Andesite Porphry)	3.16%
Point Lookout Sandstone	13.40%
Harmon Sandstone	7.74%
Menefee Shale	44.34%
Mancos Shale	12.31%
Other	6.65%

Tailings material will be characterized through the analysis of three samples collected from material produced during metallurgical test work. The material will be representative of the tailings that will be produced during operation of the mine.

7.7 Parameters to be Analyzed

Static Test Work

Each sample will be analyzed initially using a standard Acid Base Accounting (ABA) method including analyses for various sulfur compounds and a net acid generating procedure (NAG). A broad analytical suite for trace elements and a Meteoric Water Mobility Procedure (MWMP) will be used on representative samples from each significant geologic unit encountered. Additionally, the mineral content and the textural relationships within the rock will be described in detail for each geologic unit. If appropriate, an inorganic carbon analysis will also be conducted as an indication of carbonate abundance, as carbonates are generally the predominant neutralizing material and represent readily available and reactive neutralizing capability. This analytical package will generally allow for interpretation of chemical and mineralogical characteristics of potential ARD generation and neutralization, and permit the identification of samples for which kinetic testwork is required.

Static Test work will consist of the following for all samples:

- Acid/Base Accounting (ABA) and Sulfur Forms Analysis using Modified Sobek Method
    - ABA, Acid Generation Potential (AGP), Acid Neutralization Potential (ANP), Non-extractable sulfur, Non-sulfate sulfur, Pyritic Sulfur, Sulfate Sulfur, Total Sulfur

- Net Acid Generating Procedure (NAG) using AMIRA P387A Project Test Handbook Method

Static Test work will include the following for a subset of representative samples from each significant geologic unit encountered:

- Strong Acid Digestion and Multi-Element Trace Analysis by ICP and other appropriate analysis methodologies for parameters listed in 19.8.803.B.1.b NMAC:
    - Aluminum (Al), Arsenic (As), Barium (Ba), Boron (B), Cadmium (Cd), Chromium(Cr), Cobalt (Co), Copper (Cu), Cyanide (CN), Fluoride (F), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Silver (Ag), Sulfate (SO4), Uranium (U), Vanadium (V), Zinc (Zn), Radioactivity, Radium Ra226, Selenium (Se), Radium Ra228

- Meteoric Water Mobility Procedure (MWMP) and analysis of rinsate to determine short term leaching of metals. Proposed parameters include those listed in the Nevada Department of Environmental Protection (NDEP) Profile II suite including:
    - Alkalinity (Bicarbonate (as $CaCo_3$)), Alkalinity (Total (as $CaCo_3$)), Aluminum (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Bismuth (Bi), Boron (B), Cadmium (Cd), Calcium (Ca), Chromium(Cr), Cobalt (Co), Copper (Cu), Cyanide (CN), Fluoride (F), Gallium (Ga), Iron (Fe), Lead (Pb), Lithium (Li), Magnesium (Mg), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Nitrate + Nitrite as Total N, Nitrogen Total, pH, Phosphorous (P), Potassium (K), Scandium (Sc), Selenium (Se), Silver (Ag), Sodium (Na), Strontium (Sr), Sulfate (SO4), Thallium (Tl), Tin (Sn), Titanium (Ti), Total Dissolved Solids, Vanadium (V), Zinc (Zn)
    - Elements may be added or removed if they are detected or not detected in ICP analysis for selected geologic materials

- Total Inorganic Carbon

- The mineral content and the textural relationships within the rock will be described in detail for each geologic unit. Existing reports should provide these data; however petrographic analysis of samples may be conducted on representative samples.

Kinetic Test Work

Kinetic tests provide a measure of the dynamic performance or “reactivity” of excavated and exposed materials. Kinetic tests will be used to determine the rates of sulfide oxidation (acid generation), neutralization, and metal leaching. Kinetic Tests may also be used to design and test potential control or treatment techniques for material stockpiles and mitigation measures. Humidity cells and/or column tests may be employed for kinetic testing. Kinetic tests will be used on materials that have been identified to be potentially acid forming or uncertain.

Preparation of samples will take into account the liberation size for potentially ARD generating minerals. These will be estimated from petrographic studies, especially the microscopic examination of thin and polished sections. Estimated size distributions will also be determined from proposed mining method and milling procedures. It is anticipated that material will be deposited aerially and kinetic testing methodologies will attempt to mimic the depositional environment as closely as possible. The ASTM Procedure for kinetic testing requires a minimum of 20 weeks although tests may be run in excess of that time.

Analysis of rinsate from kinetic test will be conducted in accordance with standard kinetic test cell procedures including parameters listed in the Nevada Department of Environmental Protection Profile II and any other analytes of concern identified during static testing.

7.8 Maps Showing Proposed Sampling Locations

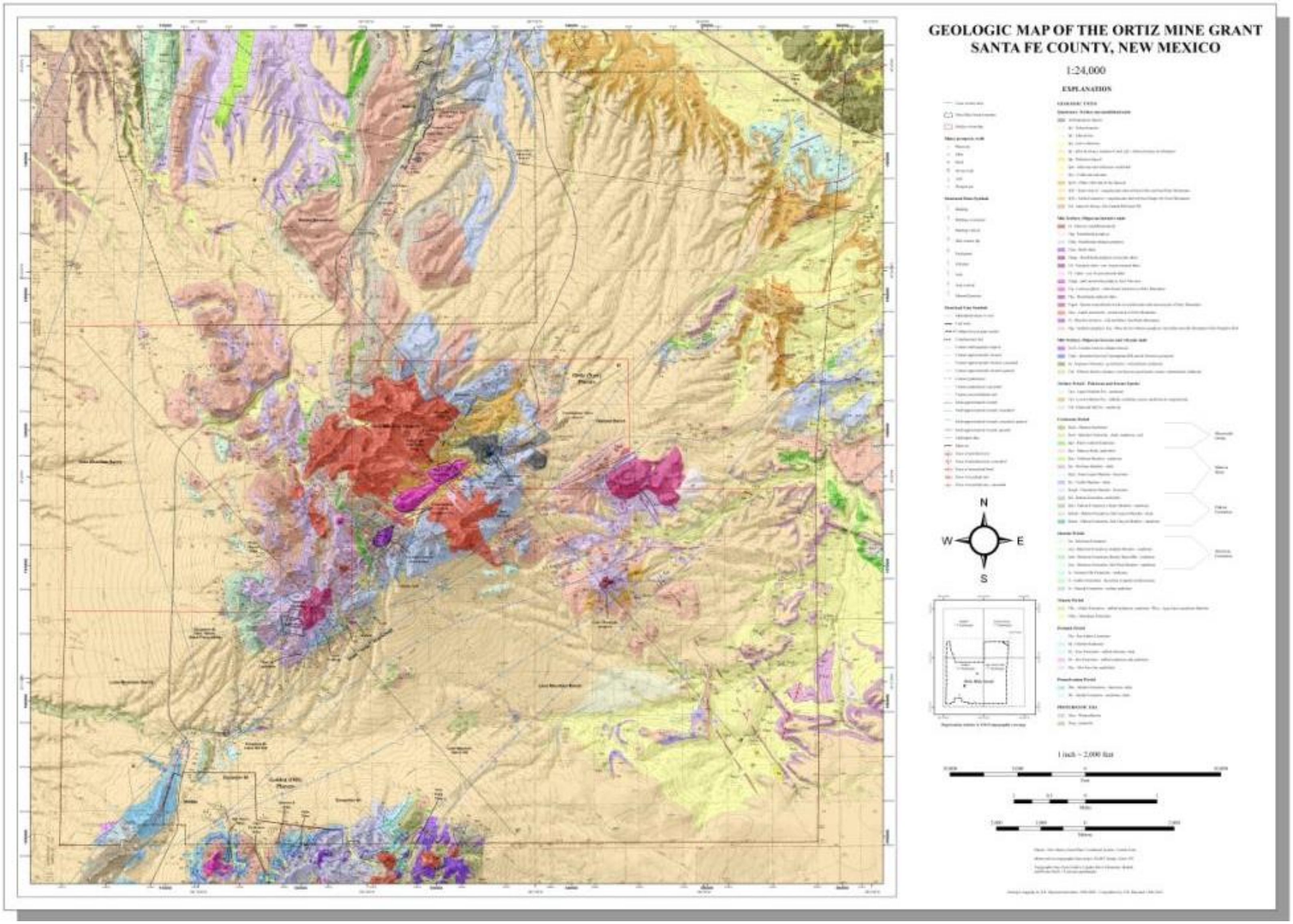


Figure 7-1. Geologic Map of the Ortiz Mine Grant, Santa Fe County New Mexico

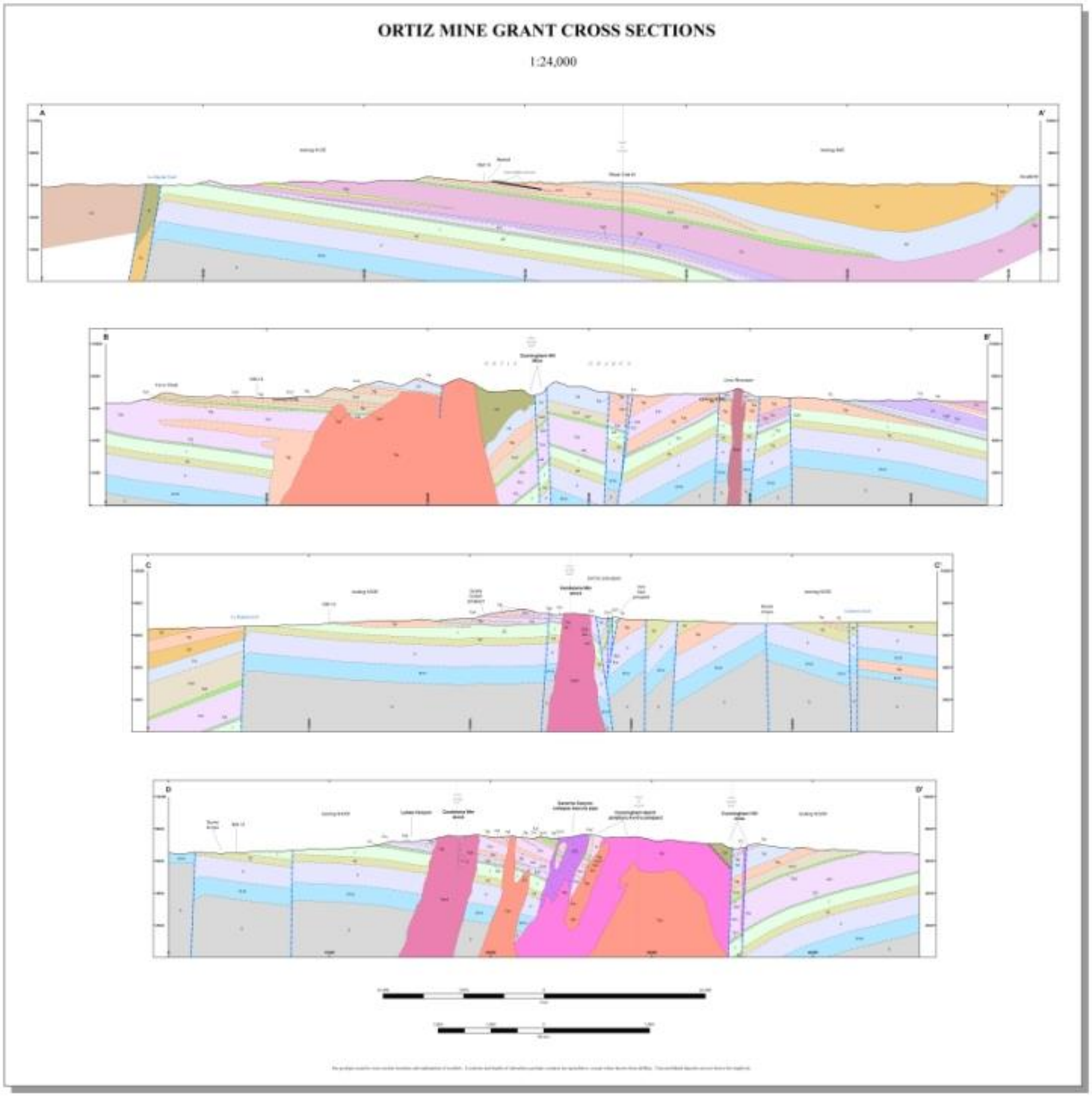


Figure 7-2. Stratigraphic cross-sections of the Ortiz Mine Grant

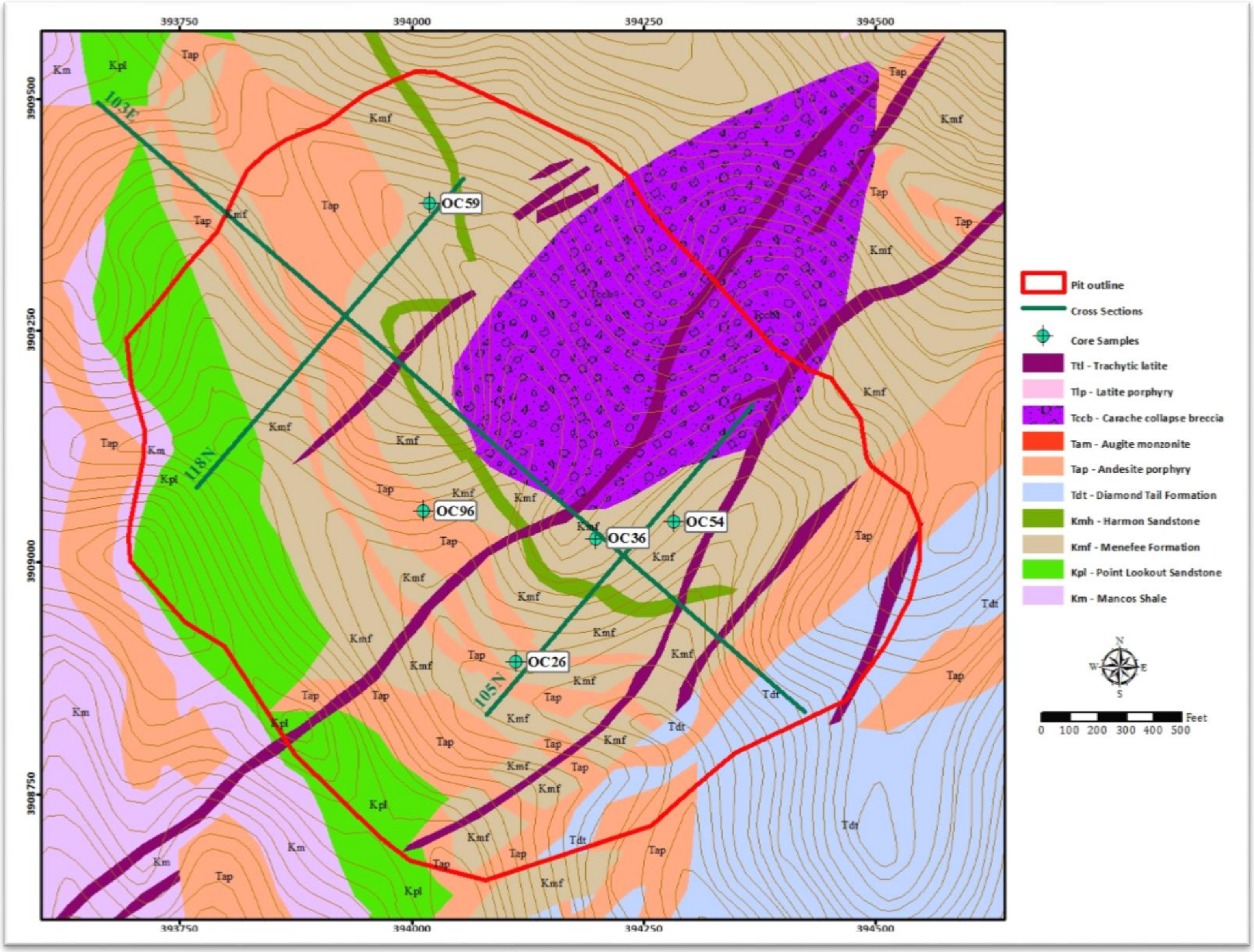


Figure 7-3. Carache Canyon Core Location Map

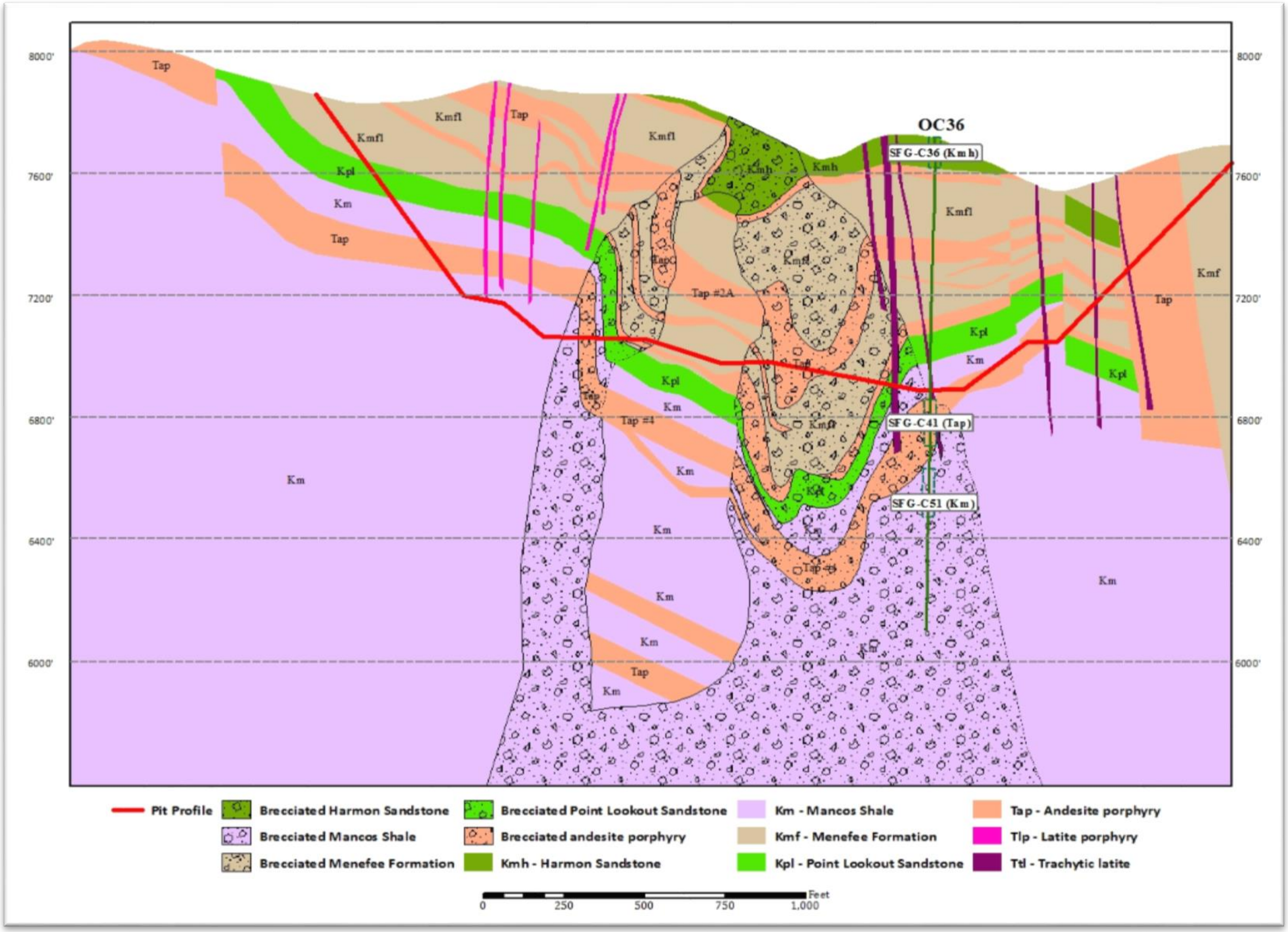


Figure 7-4. Carache Canyon Pit Cross Section 103E with Core and Sample Locations

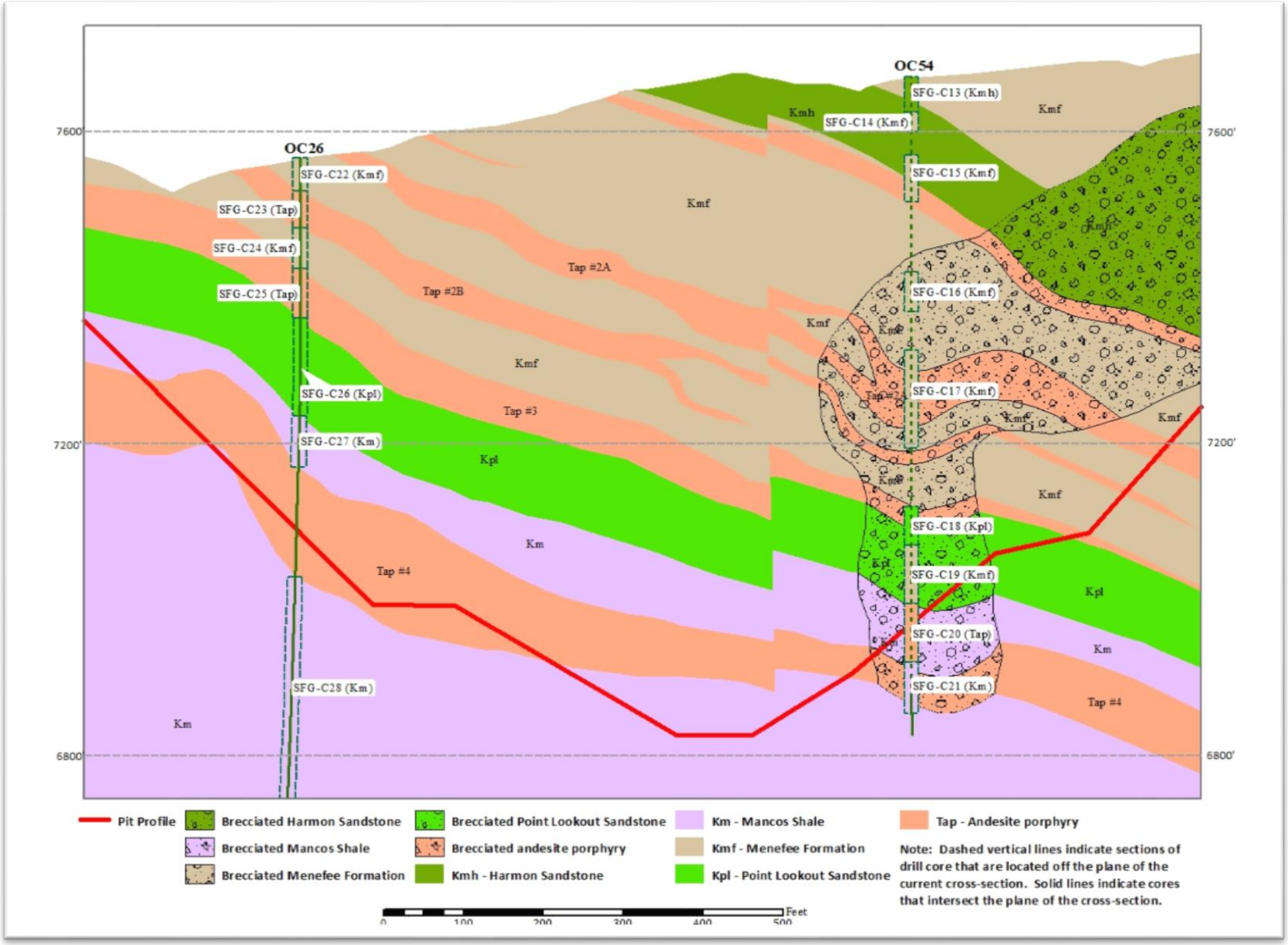


Figure 7-5. Carache Canyon Pit Cross Section 105N with Core and Sample Locations

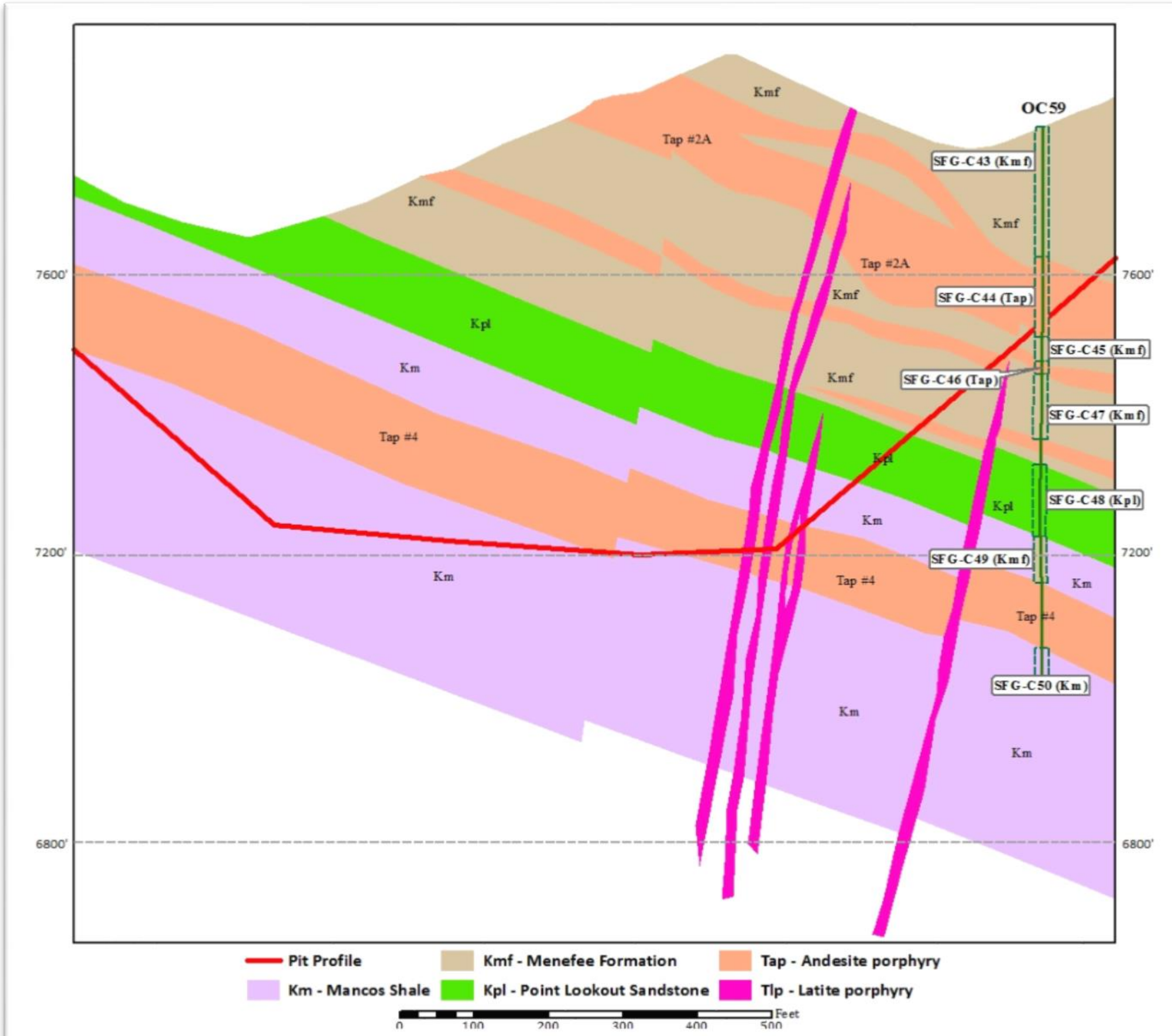


Figure 7-6. Carache Canyon Pit Cross Section 118N with Core and Sample Locations

7.9 Laboratory and field Quality Assurance Plans

The sampling and analysis methods proposed for the Mineralogy and Geology section of the SAP will be described in detail in the GL Environmental, Inc. Standard Operating Procedures (SOPs), Equipment SOPs, and Field SOPs. These documents establish procedures for quality related activities throughout the company and ensure compliance with regulatory requirements and the GL Environmental, Inc. Quality Policy. The Quality Policy is documented within the Quality Assurance Program Manual and execution of the system is described in the Quality Assurance Implementation Plan (Appendix C).

Additionally, any vendors that provide analytical data are procured through the use of a Quality Assurance Purchase Order (PO). This document requires the vendor to adhere to, at a minimum, GL's quality assurance program as well as any specifications required by the client. GL requires that any contracted analytical laboratory hold current National Environmental Laboratory Accreditation Program (NELAP) or equivalent accreditation.

Methods of sample collection, preparation and analysis will be documented in reports, chains-of-custody, and laboratory data sheets. To provide assurance as to reliability of analyses, static testing replicate samples and/or ABA reference standard will be used. Internal standards provided by analytical laboratories for both trace element and major oxide analyses will be examined in the QA data packages accompanying analytical results. Additionally, data will be plotted to look for spurious results and confidence of data.

At the present time there has been little standardization of kinetic testwork procedure with regard to sample preparation, humidity cell or column design and operation or data reporting. However, the use of duplicate kinetic tests and the use of a "blank" or "control" using non-acid generating samples may be used.

7.10 Discussion Supporting the Proposed Sampling Plan

Acid-base accounting (ABA) measures the balance between the acid-producing potential (AP) and the acid-neutralizing potential (NP). The AP is determined by sulfur analysis and determines the sulfur content associated with pyritic sulfur. The NP is determined by acid-titration and generally represents the carbonate content of the sample. The net-neutralizing potential (NNP) is the difference between these values (NNP = NP - AP) and is typically expressed in units of kilograms of calcium carbonate (CaCO3) per ton of rock (kg CaCO3/t rock, or kg/t). Hence, a negative NNP test result demonstrates that acid-producing potential exceeds acid-neutralizing potential. The NNP, together with the NP ratio (NP/AP), is an important parameter used to classify a material as potentially acid forming (PAF), Non Acid Forming, (NAF) or Acid Consuming (AC). If the NNP does not exceed +20 and/or the NP value is not at least three times greater than the AP value, the material will be classified as Uncertain (U) (Nevada BLM 2004).

Another classification scheme is based on the results from net acid generation (NAG). The static NAG test is proposed because standard ABA can overestimate acid generation potential due to the presence of non-acid forming sulfur bearing phases such as gypsum, epsomite, barite, etc. (Warwick 2006). The NAG test involves addition of hydrogen peroxide to a pulverized sample and allowing the sample to react overnight. Once the sample has cooled to room temperature, the pH and titrated acidity to pH 4.5 and 7.0 (in kg H2SO4/t of sample) of the solution are measured. A sample is classified PAF when it has a positive NAG value and NAGpH < 4.5, and NAF when it has a NAG value of zero and NAGpH ≥ 4.5. Samples are classified uncertain when there is an apparent conflict between the NNP and NAG results, i.e. when the NNP is negative and NAGpH ≥ 4.5, or when the NPP is positive and NAGpH < 4.5.

Table 7-3. Material Classification

Category	NNP	NPR Value	NAGpH
Potentially Acid	NNP < -20	NPR < 1	<4.5
Non Acid Forming	NNP > +20	NPR > 3	≥4.5
Acid Consuming (AC)	NPP > +200	NPR > 3	≥4.5
Uncertain	NNP between -20 and +20	NPR between 1 and 3	Not in agreement with NPP / NPR

Representative samples of material identified as PAF or U will be included in a kinetic testing system. It is anticipated that consultation with New Mexico MMD and other appropriate state agencies will be conducted prior to initiation of kinetic testing to establish sufficient sampling program.

8 Surface and Groundwater

8.1 Surface Water

The proposed mine area and surrounding Ortiz Mine Grant are located within the Rio Grande Watershed in the north-central portion of New Mexico (Figure 8-1). The northeastern half of the Ortiz Mountains drains to the Galisteo Creek watershed, and the southwestern half of the Ortiz Mountains drains to the Arroyo Tuerto watershed and other small drainages that are tributary to the main-stem of the Rio Grande. The watershed area of Arroyo Tuerto, including the tributaries Lukas Canyon and Carache Canyon, encompass the proposed mine permit area and the watershed area of interest (Figure 8-2).

With high evaporation and low precipitation, and with the ephemeral nature of drainages in the Ortiz Mine Grant area, surface water is not a reliable source.

8.1.1 Surface-Water Characteristics of Site and Vicinity

Storm-water runoff is not a reliable source of water in the Ortiz Mountains, as a result groundwater near and within the proposed mine permit boundary is relied upon for almost all uses, including agriculture (mostly stock watering) and domestic use. Seasonally, storm-water runoff may be captured locally in stock tanks and used for stock watering. Several springs occur around the peripheral flanks of the Ortiz Mountains, many of which are dependent on shallow perched aquifers, and may not run year-round (Table 1, and Figure 8-3). There are no springs in the proposed mine permit area. Tuerto Spring is the only known spring down-gradient of the proposed mine permit area (Figure 8-3).

The nearest perennial stream is the Rio Grande, which occurs approximately 17 miles to the northwest of the proposed mine permit site. Galisteo Creek is approximately 8 miles to the north, but the majority of the reach is ephemeral and intermittent rather than perennial. Storm-water runoff from the proposed mine permit area would potentially collect in Carache and possibly flow downstream to Arroyo Tuerto, into Arroyo Tonque, and then into the Rio Grande near San Felipe Pueblo (Figs. 8-1 and 8-2). Hydrologic divides surrounding the proposed mine sites are illustrated on Figure 8-1, and the watershed containing the proposed mine permit area is shown on Figure 8-2. Following is a description of the surface-water features on or near the Ortiz Mine Grant.

8.1.1.1 Watershed Area

The Rio Grande watershed which contains the Ortiz Mine Grant encompasses a good portion of central New Mexico (Figure 8-1). The watershed containing the proposed mine permit area and receiving water courses are presented on Figure 8-2. The upper drainages of Cañon Monte del Largo, and Carache and Lukas Canyons, drain into Arroyo Tuerto, and the Gypsy Queen watershed drains into Arroyo Coyote. Areas north and northeast of the watershed boundary such as Cunningham Gulch, Dolores Gulch, and Galisteo Creek are not being considered for this SAP because they are hydrologically separated from the proposed mine permit area.

8.1.1.2 Stream Types

Stream types include perennial, intermittent, and ephemeral. Perennial streams convey surface water year around and typically are connected to the water table. Intermittent streams flow seasonally and are typically connected to the water table when flowing. Ephemeral streams convey storm-water runoff that occurs after high intensity precipitation events, and are well above the regional water table. There are no perennial or intermittent streams in the Ortiz Mine Grant and vicinity. All drainages are ephemeral, and convey storm-water runoff during high intensity precipitation events that most commonly occur during the summer months of July and August. Drainages in the proposed mine permit area (Carache Canyon, Lukas Canyon, Cañon Monte del Largo, Gypsy Queen Canyon, and Arroyo Tuerto) are all ephemeral drainages. Figure 8-2 illustrates the locations of ephemeral streams in or near the Ortiz Mine Grant.

8.1.1.3 Watershed Yield

Storm-water runoff from the proposed mine permit area varies year to year. Surface flow is highly dependent on storm events and climate conditions such as prolonged drought or above-average precipitation. According to Shomaker (1995), the overall runoff from the Ortiz Mountains, which recharges sedimentary rocks surrounding the range, is estimated to be 1,480 acre-feet per year (ac-ft/yr). Fleming (1991) prepared a watershed analysis report of the Ortiz Mountains, and calculated the average surface water yield in the Ortiz Mountains to be approximately 11.5 ac-ft of water per square mile per year. Fleming (1991) estimated the average annual discharge from Carache Canyon at 10.0 ac-ft/yr. Fleming's analysis was based on 29 years of gaging data from the Galisteo Creek watershed between 1941 and 1971.

8.1.1.4 Receiving Waters

Receiving waters from the proposed mine permit area can be divided into two segments: 1) storm-water runoff from Gypsy Queen Canyon flows to Arroyo Coyote, and 2) storm-water runoff from Cañon Monte Largo, Lukas Canyon, and Carache Canyon flow to Arroyo Tuerto into Arroyo Cuchillo and into Arroyo Una de Gato (Figure 8-2). Arroyo Coyote and Arroyo Una de Gato merge to form the Arroyo Tonque. The Arroyo Tonque flows into the Rio Grande. However, most of the runoff from the watershed encompassing the proposed mine permit area infiltrates into fractured rock and alluvial sediments, or is evapotranspired before traveling the full length from the Ortiz Mountains to the Rio Grande. Infiltration of storm water into fractured rock and alluvial fans around the flank of the Ortiz Mountains is one of the primary sources for recharge to groundwater (Shomaker, 1995).

8.1.1.5 Springs

Several springs occur in the vicinity of the Ortiz Mine Grant, but none have been identified in the proposed mine permit area (Figure 8-3). Known springs are listed in Table 8-1 and illustrated on Figure 8-3. Springs are usually dependent on shallow perched groundwater that is diverted laterally to the surface by a relatively impermeable layer of sediment such as clay, silt, or a relatively impermeable rock layer. Some springs are intermittent, so do not flow at all times, and may not flow at all in some years or during drought periods. Flow from springs, however, is generally more reliable than storm water in the Ortiz Mine Grant area. The only spring within the potential area of hydrologic influence from the proposed mining operation is Tuerto Spring (Figure 8-3).

8.1.1.6 Other Surface Water Features

No wetland areas are known within the proposed mine permit area or the surrounding Ortiz Mine Grant. Small localized wet zones may occur in the vicinity of springs. Riparian areas may occur in the vicinity of Galisteo Creek. There are no known lakes or reservoirs in the vicinity of the Ortiz Mine Grant and proposed mine permit area. There are several stock tanks that contain seasonally captured storm-water runoff in the proposed mine permit area.

Table 8-1. Springs in the Ortiz Mountains and vicinity

*UTM meters, Zone 13		Spring name	NMOSE reference No.	elevation (ft)
easting	northing			
404235	3915667	Unknown Spring 2		5,950
389408	3904821	Tuerto Spring		6,500
389865	3915605	Unknown Spring 1		6,340
393764	3911837	Unknown Spring 4	02670	7,560
403785	3916221	Hillside Spring	02229	6,000
398187	3912178	Upper Universal Spring		6,610
398251	3912421	Lower Universal Spring	02225	6,595
397366	3912523	Las Norias Spring	02228	6,630
397061	3912314	Deer Lick Spring	02232	6,690
397086	3911856	Dolores Spring	02223	6,770
399612	3909173	Cañamo Spring	02671	6,520
398935	3918264	Oak Spring	02231	6,030
400361	3917819	Coyote Spring	02230	5,960
401031	3917750	Cottonwood Spring	02224	5,960
386747	3911286	Unknown Spring 3		6,365

*UTM - Universal Transverse Mercator projection using North American Datum 1983
NMOSE - New Mexico Office of the State Engineer, ft=feet or foot

8.1.2 Historical Data

Historical surface-water data are available for the Ortiz Mine Grant because mining in the area was conducted in the past, and some surface-water conditions were characterized for previous mining operations (Gold Fields, Pegasus, LAC, etc.). These historical data will be used in conjunction with, and as a general guide to, collecting baseline surface-water quality and parameter data collected as a result of this SAP.

There are no known historical data pertaining to surface-water analysis of storm-water runoff from the drainages in the proposed mine permit area. However, there are limited data from Tuerto Spring, which are summarized in Table 8-2.

Table 8-2. Summary of water-quality data for Tuerto Spring

date	measured discharge rate (gpm)	water temperature (˚F)	pH	specific conductance (µS/cm)	total alkalinity (mg/L as CaCO3)
6/6/1991	19.5	66	6.45	1,250	165
10/2/1991	20.5	66	6.50	1,150	nm
12/13/1991	12.7	50	6.70	1,200	nm
6/25/1992	28.0	58	7.00	800	nm
10/1/1992	18.5	63	7.00	1,300	180

8.1.3 Surface-Water Sampling Plan

The surface-water sampling plan will focus on defining the baseline characteristics of surface water generated from the proposed mine permit area.

8.1.3.1 Sampling Objectives

The objectives of baseline surface-water characterization are based on the following:

- Obtaining necessary and appropriate data to evaluate quantity and quality of surface water at the site that could be impacted by mining activities.
- Meeting the requirements set forth in NMAC Title 19, Chapter 10, Part 6.
- Meeting guidelines set forth in the New Mexico Mining and Minerals Division (MMD) Draft Guidance Document for Part 6, New Mining Operations Permitting under the New Mexico Mining Act.

The objective of the surface-water data collection program is to obtain data necessary to establish baseline conditions so the potential impacts of mining activities can be estimated, including the proposed mine's impact on surface water. The mine permit area and the surrounding Ortiz Mine Grant have been mined in the past and the area has been subject to several permitting cycles. Historical data, therefore, play an important role in the evaluation of potential impacts. Concurrent evaluation of historical data will be done as appropriate and where available.

Measured volumes and water-quality data will be used to determine the current condition of surface waters, and will be compared to available historical data, preferably from locations that were sampled in the past. These current and historical data will be evaluated to determine a range of baseline surface-water conditions in the watershed area containing the proposed mine permit area.

8.1.3.2 Sampling Frequency

A minimum of four sampling events over the 12-month period (quarterly) is proposed for surface-water characterization. New Mexico Administrative Code (NMAC) Title 19, Chapter 10, Part 6, requires a minimum of two sampling events over the course of a 12-month period to acquire baseline water-quality data, and quarterly sampling is required to address New Mexico Environment Department (NMED) discharge plan requirements. Because of this, baseline sampling will be performed for a minimum of four quarters.

8.1.3.3 Data to be Collected

Surface-water sampling locations will include the following:

a. Tuerto Spring
b. Storm-water runoff station at the mouth of Carache Canyon
c. Storm-water runoff station at the mouth of Lukas Canyon
d. Storm-water runoff station at the mouth of Cañon Monte del Largo
e. Storm-water runoff station in Arroyo Tuerto between the confluence of Lukas Canyon and Carache Canyon
f. Storm-water runoff station in Arroyo Tuerto approximately 1/4-mile downstream of Tuerto Spring
g. Storm-water runoff station in Cañon Monte del Largo near State Highway 14

Proposed surface-water sampling locations are shown on Figure 8-4. Surface water in and around the site is ephemeral, and water-quality samples will be collected if runoff events occur. Proposed surface-water sampling locations are approximate, and the actual sample locations will be determined by field professionals in concert with the objectives of this SAP and field conditions. The locations for measuring storm-water runoff rates and volume will be based on feasibility of flow measurement and channel conditions (e.g., areas with braided channels are not suitable for measuring flow rates).

8.1.3.4 Data Collection Methods

Surface-water data will be collected in the field in accordance with applicable John Shomaker and Associates, Inc. (JSAI) Standard Operating Procedures (SOP) and JSAI quality assurance plan (QAP). Appendix C contains a copy of the JSAI sampling SOP and QAP. Laboratory analysis will be conducted by a certified laboratory in accordance with the lab’s Laboratory Quality Assurance Plan.

Staff gages would be installed at each proposed storm-water runoff station to measure crest-stage height of arroyo and overland flow. The observed cork-line heights will correspond to crest-stage flows at each gage. The cross-sectional area of the station will be measured upon installation of each staff gage. Watershed characteristics (area, slope, vegetative density, soil characteristics, etc.) upstream of each station will be defined from existing reports, topographic maps, aerial photographs, and field investigation. Storm-water runoff rates and volumes will be calculated from the staff-gage data using methods described in the Natural Resource Conservation Service (NRCS) Hydrology National Engineering Handbook (NRCS, 1997).

To collect storm-water runoff samples for laboratory analysis, sample bottles will be paired with staff gages. If water is present in sample bottles at the time of quarterly staff-gage measurements, the water will be transferred to sample bottles provided by the laboratory for analysis. Real-time precipitation data will be monitored to determine when a runoff event occurs. Each storm-water station will be field checked after a 24-hour precipitation event of 1 inch or greater.

Samples from Tuerto Spring will be collected as grab samples if spring flow is observed. Discharge rates from Tuerto Spring will be determined by constructing a temporary weir directly downstream of the point of discharge. A standard 60-degree notch weir and conversion table will be utilized.

8.1.3.5 Surface-Water Analysis

Constituents to be analyzed for in surface water include field and inorganic parameters recommended in the MMD Part 6 guidance document for new mines. Table 8-3 contains a list of analytical parameters, analysis methods, NMWQCC standards, and laboratory detection limits. All surface-water samples will be analyzed for total metal concentration.

Table 8-3. Proposed water analysis parameters, corresponding analysis methods, NMWQCC standards, and laboratory detection limits.

analytical parameter	analysis method	NMWQCC standard	detection limit
temperature	field instrument	none	±0.1 units
specific conductance	field instrument	none	±0.1 units
pH	field instrument	pH between 6 and 9	±0.1 units
total suspended solids	SM 2540D		1.0 mg/L
total dissolved solids (TDS)	SM 2540C	1,000 mg/L	10 mg/L
total alkalinity -bicarbonate	SM 2320B		20 mg/L
sulfate	EPA Method 300.0	600 mg/L	0.5 mg/L
chloride	EPA Method 300.0	250 mg/L	0.1 mg/L
fluoride	EPA Method 300.0	1.6 mg/L	0.1 mg/L
nitrate (NO3 as N)	EPA Method 300.0	10 mg/L	0.1 mg/L
calcium	EPA Method 200.7		0.5 mg/L
magnesium	EPA Method 200.7		0.5 mg/L
sodium	EPA Method 200.7		0.5 mg/L
potassium	EPA Method 200.7		1.0 mg/L
aluminum	EPA Method 200.7	5 mg/L	0.02 mg/L
antimony	EPA Method 200.7		0.005 mg/L
arsenic	EPA Method 200.7	0.1 mg/L	0.02 mg/L
barium	EPA Method 200.7	1 mg/L	0.002 mg/L
beryllium	EPA Method 200.7		0.002 mg/L
boron	EPA Method 200.7	0.75 mg/L	0.04 mg/L
cadmium	EPA Method 200.7	0.01 mg/L	0.002 mg/L
chromium	EPA Method 200.7	0.05 mg/L	0.006 mg/L
cobalt	EPA Method 200.7	0.05 mg/L	0.006 mg/L
copper	EPA Method 200.7	1 mg/L	0.0003 mg/L
cyanide	Kelada-01	0.2 mg/L	0.005 mg/L
iron	EPA Method 200.7	1 mg/L	0.02 mg/L
lead	EPA Method 200.7	0.05 mg/L	0.005 mg/L
manganese	EPA Method 200.7	0.2 mg/L	0.002 mg/L
total mercury	EPA Method 7470	0.002 mg/L	0.0002 mg/L
molybdenum	EPA Method 200.7	1 mg/L	0.008 mg/L
nickel	EPA Method 200.7	0.2 mg/L	0.01 mg/L
selenium	EPA Method 200.8	0.05 mg/L	0.02 mg/L
silver	EPA Method 200.7	0.05 mg/L	0.005 mg/L
uranium	EPA Method 200.8	0.03 mg/L	0.01 mg/L
zinc (Zn)	EPA Method 200.7	10 mg/L	0.005 mg/L

NMWQCC - New Mexico Water Quality Control Commission
EPA - U.S. Environmental Protection Agency
mg/L - milligrams per liter

8.1.3.6 Sediment Analysis

Attempts will be made to collect surface-water samples as practical, but in the absence of adequate and representative surface water during scheduled sampling events, analysis of sediment from streambeds may be used in lieu of surface water. Table 8-4 contains a list of sediment sample analysis parameters recommended in the MMD Part 6 guidance document that would be performed in the absence of flowing surface water. In addition, field characterization of sediment such as grain size distribution, rock fragment analysis, and descriptions of geologic settings of the sample sites would be performed by a professional geologist. All sediment samples will be analyzed for total metal concentration.

Table 8-4. Proposed sediment analysis parameters, methods, and detection limits

parameter	analysis method	detection limit
pH	paste method	±0.1 units
electrical conductivity		20 µS/cm
saturation percentage	wet/dry density	±5%
particle size distribution		
rock fragment		
arsenic	EPA Method 200.7	0.02 mg/L
barium	EPA Method 200.7	0.002 mg/L
cadmium	EPA Method 200.7	0.002 mg/L
chromium	EPA Method 200.7	0.006 mg/L
cobalt	EPA Method 200.7	0.006 mg/L
copper	EPA Method 200.7	0.0003 mg/L
lead	EPA Method 200.7	0.005 mg/L
manganese	EPA Method 200.7	0.002 mg/L
mercury	EPA Method 7470	.0002 mg/L
molybdenum	EPA Method 200.7	0.008 mg/L
nickel	EPA Method 200.7	0.01 mg/L
selenium	EPA Method 200.8	0.02 mg/L
silver	EPA Method 200.7	0.005 mg/L
zinc	EPA Method 200.7	0.005 mg/L

EPA - United States Environmental Protection Agency
mg/L - milligrams per liter
µS/cm - microSiemens per centimeter

8.1.3.7 Laboratory and Field Quality Assurance Plans

Baseline water-quality sample collection will be done in accordance with current industry practices and in accordance with the JSAI field Quality Assurance Plan (QAP). A copy of the JSAI field QAP is included in Appendix C. Analysis of water samples will be done in accordance with applicable Environmental Protection Agency (EPA) methods and the laboratory QAP.

8.1.3.8 Discussion Supporting the Surface-Water Analysis Proposal

The proposed surface-water analysis plan will provide the data needed to characterize baseline conditions for rate, volume, and quality of surface water in the mine permit area and receiving water courses. The only historical surface-water data pertain to Tuerto Spring. Quantifying storm-water runoff will be important for planning and designing proposed mine facilities and associated proposed surface-water and groundwater monitoring networks.

8.2 Groundwater

General groundwater information such as anticipated local and regional aquifers as well as the anticipated depths to groundwater is included in this SAP. Mine dewatering will not be required because the proposed mine pit is above the measured regional groundwater level elevations. Some baseline studies have been completed for proposed mining projects in the early 1990s. For example, historical pumping test and aquifer testing data from the proposed mine permit area are available; therefore a pumping test or other aquifer testing will not be needed to better characterize the potential impact to both surface water (i.e., quantity and quality of discharged water) and groundwater (i.e., cone of depression, potential impacts to users, alteration of the regional groundwater flow direction).

8.2.1 Groundwater Characteristics of the Site and Vicinity

Groundwater is the primary supply of water for domestic, industrial, and agricultural use in the project area. There is a hydrologic divide in the Ortiz Mountains that separates the New Mexico Office of the State Engineer (NMOSE) defined Northern Rio Grande groundwater basin from the Middle Rio Grande groundwater basin (Figure 8-5).

8.2.1.1 Regional Hydrogeology

The Ortiz Mine Grant site is located on the eastern edge of the Middle Rio Grande Underground Water Basin (as determined by the NMOSE), which covers 3,060 square miles and encompasses parts of Santa Fe, Sandoval, Bernalillo, Valencia, Socorro, Torrance, and Cibola Counties. The Middle Rio Grande Basin lies within the Rio Grande valley which was created by rifting of continental plates approximately 25 million years ago. The complexity of regional geologic structures within the basin results in much variability in the quality and size of aquifers contained within (Bartolino, 2002). The Ortiz Mountains were formed by a series of igneous rocks (Ortiz porphyry belt) intruded into sedimentary rocks along the Tijeras-Cañoncito Fault System that bounds the eastern margin of the Rio Grande rift (Maynard, 1995; Abbott et al., 2004). Figures 8-6 and 8-7 illustrate the regional geologic features.

There are two primary aquifer systems in the region of the Ortiz Mine Grant: 1) Sedimentary Rock Aquifer, and 2) Igneous Rock Aquifer (Figs. 8-6 and 8-7). The Basin-Fill Aquifer, associated with the Rio Grande rift, is found west and northwest of the Ortiz Mine Grant, and more than 6 miles northwest of the proposed mine permit area (Figure 8-6).

Faults associated with the Tijeras-Cañoncito Fault System and La Bajada Fault play a significant role in the regional hydrogeology by acting as conduits for conveying recharge and as barriers to groundwater flow (Shomaker and Mahar, 1993).

8.2.1.2 Local Hydrogeology

The current understanding of the local hydrogeology within the proposed mine permit area has been previously studied in great detail (Shomaker and Mahar, 1993; Shomaker, 1995), which included the analysis of groundwater conditions from drilling 386,000 ft of mineral exploration core. The geologic structure of the Ortiz Mountains is an expression of thick latite-andesite porphyry sills that intruded sedimentary rocks, which were later penetrated by breccia pipes. The Tijeras-Cañoncito Fault System penetrates the Ortiz Mountains range southwest to northeast, and locally the Golden Fault Zone (GFZ) forms a zone of high transmissivity (Figure 8-6).

The Sedimentary Rock Aquifer within the Ortiz Mountains is comprised of, from oldest to youngest, the Madera Formation, San Andres Limestone, Glorieta Sandstone, Chinle Formation, Morrison Formation, Mancos shale, Mesaverde Group, Galisteo Formation, and Diamond Tail Formation. The Sedimentary Rock Aquifer stratigraphy encompasses layers of limestone, sandstone, mudstone, and shale. Position of the layers has been structurally altered by the Tijeras-Cañoncito Fault System (Figure 8-7).

The Igneous Rock Aquifer is composed of Tertiary-age dikes, sills, and laccoliths, subvolcanic intrusives, quartz monzonite stocks, augite monzonite stock, and the collapse breccias (Shomaker, 1995; Maynard, 2013). The Igneous Rock Aquifer also includes altered and mineralized sedimentary rocks adjacent to the emplaced igneous rocks.

The Tijeras-Cañoncito Fault System is a regional strike-slip system with lateral movement. Within the Tijeras-Cañoncito Fault System there are several horst (up-lifted block) and graben (down-thrown block) features (Abbott et al., 2004). The geologic structures and stratigraphy have been mapped in detail by Maynard (2013), particularly the collapsed breccia-pipe feature within the Ortiz Mountains.

Aquifer transmissivity in the Ortiz Mine Grant is locally influenced by fracture flow, especially those completed in or near the Golden Fault Zone, so does not represent the inherent transmissivity of the formations without fracturing. An example of this is two wells completed in the Sedimentary Rock Aquifer (Morrison Formation), one near the fracture zone, and the other far from the fracture zone. In the well near the fracture zone transmissivity was estimated at 16,000 ft2/day, and in the well far from the fracture zone the transmissivity was calculated to be 0.10 ft2/day (Shomaker, 1995).

A summary of the groundwater hydrology of the Ortiz Mountains and vicinity, encompassing the Ortiz Mine Grant, can be found in a paper by Shomaker (1995). This paper is included in Appendix D and the abstract is repeated here:

> Runoff from the Ortiz Mountains recharges sedimentary rocks peripheral to the range at about 1,480 ac-ft/yr, and moves radially away, draining to Arroyo Tuerto, Arroyo la Joya, Galisteo Creek, and the Rio Grande. A small proportion emerges as springs. Transmissivity of the sedimentary beds is markedly enhanced in and near the Golden fault zone. Within the Ortiz range, the small recharge moves vertically, mostly in fractures, under unsaturated conditions. Except for the Golden fault zone, which receives large recharge and is saturated to an elevation of about 7,200 ft at Carache Canyon, the top of the saturated zone within the mountains may be below 6,800 ft. Transmissivity of the fault zone is 400-440 ft^2/day.

Historical water-level data were used to create a water-level elevation map of the Ortiz Mine Grant area (Figure 8-8). This map shows the general direction of groundwater flow in and around the Ortiz Mountains, and shows that groundwater paths in the proposed mine permit area follow the topographic expression of the Ortiz Mountains and surrounding areas. As discussed by Shomaker (1995), and not shown on Figure 8-8, the water-table elevation in the Golden Fault Zone locally has a higher elevation than the water level elevation in surrounding Igneous Rock and Sedimentary Rock Aquifers. Regional groundwater flow is to the southwest and west.

During March and April 2013, JSAI performed a field reconnaissance of wells and piezometers in the proposed mine permit area (Figure 8-8). All of the piezometers located in Lukas and Carache Canyons were dry, and depth to water is likely over 1,000 ft below ground level (bgl). The regional water table beneath the Ortiz Mountains appears to be less than an elevation of 6,600 ft above mean sea level (amsl) (C398.1R, Figure 8-8), and in the Golden Fault Zone the water elevation is about 7,000 ft amsl (CC-GM-2, Figure 8-8).

Most water supply wells in the Ortiz Mine Grant have been permitted by the NMOSE for domestic and stock water uses (Figure 8-9). In the proposed mine permit area there are several stock wells (equipped with windmills) and a few wells permitted for irrigation (Figure 8-9).

Depth to water in the proposed mine permit area ranges from about 300 to over 1,000 ft bgl, which is illustrated on the hydrogeologic cross-sections presented as Figure 8-7. The regional water table beneath the Ortiz Mountains is believed to be relatively flat at an elevation of 6,800 ft amsl, and any groundwater encountered above this elevation is recharge that is migrating downward. However, the elevation of the regional water table appears to vary according to climate cycles as evidenced by observed 6,800 ft elevation during the high precipitation period of the early 1990s, and approximately 6,600 ft elevation during the current drought conditions of the last several years.

8.2.2 Historical Data

Historical groundwater data are available for the Ortiz Mine Grant site because mining in the area was conducted in the past, and groundwater conditions were characterized by previous studies (Shomaker and Mahar, 1993; Shomaker, 1995). The historical groundwater data will be used in conjunction with, and as a general guide to, collecting baseline groundwater quality and aquifer parameter data required for the proposed Santa Fe Gold mining operation.

Identified wells in the proposed mine permit area are listed in Table 8-5, and identified mineral exploration holes that were completed as piezometers are listed in Table 8-6. Known wells are either drilled as exploratory wells for the proposed mining operation in the early 1990s, or stock wells related to the Lone Mountain Ranch. Most of the stock wells are operating windmills, with the exception of TB-13 (collapsed at 64 ft). Exploratory well LC-GM-1 has been permitted and equipped to supply irrigation water for a crop circle located due west of Highway 14. Historical groundwater-quality data are available for LC-GM-1, IV-TW-1, and CC-GM-2 (Table 8-7). Known total dissolved solids (TDS) content from wells in the Ortiz Mountains area can also be referenced from Shomaker (1995). Groundwater TDS in the Igneous Rock Aquifer ranges between 700 and 1,200 milligrams per liter (mg/L), and groundwater TDS in the Sedimentary Rock Aquifer ranges between 340 and 2,880 mg/L. The sections of the Mesaverde Formation tend to have the most elevated TDS content in the Sedimentary Rock Aquifer.

Table 8-5. Summary of wells in proposed mine permit area

name	elevation (ft amsl)	year drilled	total depth (ft bgl)	type	casing diameter (inches)	depth to water (ft)	aquifer
LC-GM-1*	6,840	1990	645	expl/irr	8-5/8	355	Sedimentary Rock
Lukas Canyon MW*	6,937	?	521	monitor	3	498	Igneous Rock
IV-TW-1*	7,080	1990	1,500	expl	8-5/8	378	Sedimentary Rock
CC-GM-2*	7,340	1990	500	monitor	2	329	Igneous Rock/GFZ
TB-4*	7,088	1958	410	stock	4	365	Sedimentary Rock
TB-11*	6,730	1958	235	stock	4	162	Sedimentary Rock
TB-12*	6,592		140	stock	4	32	Sedimentary Rock
TB-13	6,772	1956	310	stock	8-5/8	298	Sedimentary Rock
TB-14	6,682	1960	375	stock	4	204	Sedimentary Rock
TB-16*	7,100	1964		stock	4	393	Sedimentary Rock
TB-19*	6,577	1960	260	stock	4	195	Sedimentary Rock
TB-20*	6,964		299	stock	4	269	Sedimentary Rock

* proposed groundwater monitoring location
ft amsl - feet above mean sea level
GFZ - Golden Fault Zone
ft bgl - feet below ground level

Approximately 25 mineral exploration holes were known to be completed as piezometers during the early 1990s. JSAI performed a field investigation to locate existing piezometers during March and April of 2013. Two of the known piezometers are in Lukas Canyon (L355R and L561R) and the other piezometers are located in Carache Canyon (Table 8-6). The piezometers located and checked for water are shown on Figure 8-8. A good number of the piezometers could not be found, because they were likely plugged and abandoned. All of the piezometers located and checked for water were dry. It is evident that groundwater measured in piezometers during the 1990s was the result of active recharge from a period of elevated precipitation (1985 to 1995). During drought conditions, the core of the Ortiz Mountains lacks recharge and is dry.

Hydraulic properties from the Golden Fault Zone, Igneous Rock Aquifer, and Sedimentary Rock Aquifer were evaluated by Shomaker and Mahar (1993) and Shomaker (1995). A summary of hydraulic conductivity and transmissivity data is presented in Table 8-8. The hydraulic property data were derived from a number of testing methods conducted during the 1990 exploration project at Lukas and Carache Canyons.

Table 8-6. Inventory of mineral exploration holes reported to be completed as piezometers

hole ID	Lat_83	Long_83	elevation (ft amsl)	reported depth (ft)	depth to water in 1990 (ft bgl)	status 2013
L355R	35 18 18	106 11 07	7,775	305	281.5	dry
L561R	35 18 43	106 09 42	7,327	665	618.0	bridged @ 230'
C301R	35 19 19	106 10 00	7,841	725	646.0	not found
C304R	35 19 16	106 10 00	7,922	725	675.9	not found
C302R	35 19 18	106 10 01	7,865	685	660.0	dry
C236R	35 19 08	106 10 00	7,652	560	536.4	dry
C205R	35 19 13	106 10 03	7,739	650	595.0	Not found
C306R	35 19 12	106 10 06	7,676	505	dry	dry
C320R	35 19 03	106 09 47	7,510	415	331.0	bridged/P&A
C331R	35 18 58	106 09 45	7,490	500	283.4	bridged/P&A
C330.1R	35 19 01	106 09 50	7,500	325	286.1	dry
C322R	35 19 12	106 09 43	7,702	550	365.8	not found
C323R	35 19 11	106 09 41	7,712	555	503.5	covered/P&A
C321R	35 19 05	106 09 45	7,576	420	326.0	not found
C252R	35 19 09	106 09 44	7,611	735	644.5	dry
C332R	35 19 03	106 09 48	7,516	365	300.0	covered/P&A
C343R	35 19 18	106 09 57	7,753	735	290.0	not found
C268R	35 19 07	106 09 45	7,580	525	458.3	not found
C340R	35 19 19	106 09 58	7,787	735	nm	not found
C348R	35 19 13	106 09 58	7,865	575	nm	bridged/P&A
C248R	35 19 08	106 09 51	7,731	775	nm	not found
C324R	35 19 09	106 09 43	7,641	720	nm	not found
C373R	35 19 07	106 09 50	7,673	779	705.0	not found
C335R/C234	35 19 02	106 09 48	7,502	475	nm	dry
C398.1R	35 19 12	106 09 52	7,643	1,600	nm	dry

ft amsl - feet above mean sea level
ft bgl - feet below ground level
nm - not measured
P&A - plugged and abandoned

Table 8-7. Summary of historical groundwater quality data from the proposed mine permit area

constituent	unit	Carache Canyon (CC-GM-2) 3/22/1990	Lukas Canyon (LC-GM-1) 3/21/1990	Lukas Canyon (LC-GM-1) 5/7/1990	Lukas Canyon (LC-GM-1) 9/27/1990	Iron Vein (IV-TW-1) 3/9/1990	Iron Vein (IV-TW-1) 5/8/1990	Iron Vein (IV-TW-1) 9/27/1990
pH	standard	8.1	7.38	7.3	7.42	7.63	11.6	10.3
specific Conductance	µS/cm		2,300			1,900		
total dissolved Solids	mg/L	988	1,780	1,696	1,870	1,336	762	526
alkalinity	mg/L		128	116	106	112	282	
bicarbonate	mg/L		156			137		
carbonate	mg/L		<1			<1		
sulfate	mg/L	222	925	704	1069	845	135	243
chloride	mg/L	27	16.4	16	14.3	15.4	112	22
fluoride	mg/L	0.669	0.97	0.56	0.61	0.77	0.909	0.38
nitrate as n	mg/L	0.39	0.025	<0.01	0.2	0.12	0.74	0.4
calcium	mg/L		370	166	79	245	324	75
magnesium	mg/L		22.3	0.1	44.5	13.8	37.1	1.57
sodium	mg/L		69	64	26	58.3	41.3	164
potassium	mg/L		29.1	12	3.1	3.43	2.1	3.64
aluminum	mg/L	0.1	<0.01			<0.01		
arsenic	mg/L	<0.010	<0.002			0.006	0.029	
barium	mg/L	<0.5	<0.25			<0.25	<0.5	
boron	mg/L	<0.1	0.32			0.29		
cadmium	mg/L	<0.003	<0.005	<0.003	0.004	<0.005	<0.003	0.004
chromium	mg/L	0.02	<0.02	0.03		<0.02	<0.02	
cobalt	mg/L	<0.05	<0.05			<0.05		
copper	mg/L	0.02	<0.02	<0.02	2.98	<0.02	<0.02	<0.02
iron	mg/L	0.34	<0.05	<0.05	1.27	0.28	0.33	0.09
lead	mg/L	0.002	<0.01	<0.002		<0.01	<0.002	
manganese	mg/L	1.86	<0.05	<0.02	0.32	0.14	0.41	0.02
mercury	mg/L	<0.001	<0.0002	<0.001	<0.001	<0.0002	<0.001	<0.001
molybdenum	mg/L	<0.50	<0.1			<0.1		
nickel	mg/L	<0.05	<0.05			<0.05		
selenium	mg/L	0.006	<0.01	0.01	<0.005	<0.01	<0.005	<0.005
silver	mg/L	<0.01	<0.02	<0.01	0.01	<0.02	<0.01	<0.01
zinc	mg/L	0.01	0.07	<0.01	0.01	0.33	0.13	0.01
cyanide	mg/L			<0.003	<0.02		<0.003	<0.02

mg/L - milligrams per liter
µS/cm - microSiemens per centimeter

Table 8-8. Summary of hydraulic properties derived from aquifer tests performed on piezometers and wells in the proposed mine permit area

ID	hydraulic conductivity (ft/day)	transmissivity (ft^2/day)	type test	aquifer or formation tested
OC134 (185-225)	0.130		pressure-injection	GFZ
OC134 (460-500)	0.520		pressure-injection	GFZ
C375.1C (450-875)	0.055		pressure-injection	Igneous Rock
C375.1C (510-550)	0.014		pressure-injection	Igneous Rock
C375.1C (550-590)	0.017		pressure-injection	Igneous Rock
C375.1C (710-750)	0.270		pressure-injection	Igneous Rock
C330.1C (460-500)	0.032		pressure-injection	Igneous Rock
C330.1C (620-660)	0.077		pressure-injection	Igneous Rock
OC134 (280-320)	0.090		pressure-injection	Sedimentary Rock
OC134 (380-420)	0.019		pressure-injection	Sedimentary Rock
C375.1C (400-440)	<0.001		pressure-injection	Sedimentary Rock
C330.1C (540-580)	0.016		pressure-injection	Sedimentary Rock
E8R (417-503)	1.730		slug test	Sedimentary Rock
OC134 (532-586)	0.072		slug test	Sedimentary Rock
C236R (553-558)	0.009		slug test	Sedimentary Rock
C252R (705-711)	0.004		slug test	Sedimentary Rock
C320R (365-405)	0.014		slug test	Sedimentary Rock
TB-14	50.000	3,460	pumping	Sedimentary Rock
LC-GM-1	55.200	16,000	pumping	Sedimentary/GFZ
IV-TW-1	0.067	75	pumping	Sedimentary Rock
TB-11	7.800	610	pumping	Sedimentary Rock
LM-1	0.001		pumping	Sedimentary Rock

GFZ - Golden Fault Zone

8.2.3 Groundwater Sampling Plan

The proposed groundwater sampling plan is designed to establish current baseline conditions within and down hydraulic gradient of the proposed mine permit area using existing wells and piezometers listed in Tables 8-5 and 8-6.

8.2.3.1 Sampling Objectives

- Obtaining necessary and appropriate data to evaluate quantity and quality of surface water at the site that could be impacted by mining activities
- Meeting the requirements set forth in NMAC Title 19, Chapter 10, Part 6.
- Meeting guidelines set forth in the New Mexico Mining and Minerals Division (MMD) Draft Guidance Document for Part 6, New Mining Operations Permitting under the New Mexico Mining Act.

The objective of the groundwater data collection program is to obtain data necessary to establish baseline conditions so the potential impacts of mining activities can be estimated, including the proposed mine's impact on groundwater down hydraulic gradient of proposed facilities. The mine permit area and the surrounding Ortiz Mine Grant have been mined in the past and the area has been subject to several permitting cycles. Historical data, therefore, play an important role in the evaluation of potential impacts. Concurrent evaluation of historical data will be done as appropriate and where available.

Measured water levels and water-quality data from existing wells will be used to determine the current condition of groundwater, and will be compared to available historical data. These current and historical data will be evaluated to determine a range of baseline groundwater conditions for each aquifer system in the proposed mine permit area. Water elevation data will provide up-to-date baseline potentiometric surface map, groundwater flow direction, and hydraulic gradient data. Existing aquifer test data will be used to obtain information as needed to determine aquifer hydraulic characteristics for each aquifer system. Proposed mine pits will be above the regional water table and no dewatering activities are expected in the proposed mine permit area.

8.2.3.2 Sampling Frequency

A minimum of four sampling events over the 12-month period (quarterly) is proposed for groundwater characterization. NMAC Title 19, Chapter 10, Part 6, requires a minimum of two sampling events over the course of a 12-month period to acquire baseline water-quality data, but quarterly sampling is required to address NMED discharge plan requirements. Because of this, baseline sampling will be performed for a minimum of four quarters.

8.2.3.3 Data to be Collected

Two categories of data to be collected for baseline groundwater characterization are 1) groundwater-quality data, and 2) water levels for evaluating aquifer characteristics. Proposed groundwater monitoring locations are listed in Table 8-5 and shown on Figure 8-10. In addition, accessible piezometers surveyed in 2013 (shown on Figure 8-8) will be checked quarterly for the presence of groundwater. Attempts will be made to sample groundwater from piezometers if groundwater is observed.

The MMD guidance document lists specific groundwater quality parameters that are required for compliance with baseline characterization. Table 8-3 lists parameters to be analyzed, methods of analysis, and laboratory detection limits.

Water-level data will be collected from all wells shown on Figure 8-10. For each well, measuring points will be established and surveyed for reference point elevation. Historical water-level data will be compiled so hydrographs can be constructed using historical and collected data. The proposed water-level monitoring data coupled with historical data will be sufficient enough so it can be used for determining groundwater flow direction, and for groundwater flow and solute transport models to evaluate potential impacts from proposed mine operations.

Groundwater data for the proposed mine permit area have been completed to determine characteristics such as hydraulic conductivity, transmissivity, and storativity for key aquifers underlying the site and vicinity. Details of these tests will be evaluated during the baseline characterization phase. When a source of water for the proposed mine operation is identified, additional aquifer tests may be completed if necessary.

8.2.3.4 Collection Methods

Three major categories of data will be collected for baseline groundwater characterization:

- water elevation and total depth of wells
- groundwater quality
- aquifer characteristics (conductivity, transmissivity, and storativity); if existing data are not adequate, groundwater pumping tests and other methods will be employed as appropriate for data objectives and site-specific conditions.

Groundwater data will be collected in the field in accordance with applicable JSAI Standard Operating Procedures (SOP) and JSAI quality assurance plan (QAP). Appendix C contains a copy of the JSAI sampling SOP and QAP. Laboratory analysis will be conducted by a certified laboratory in accordance with the laboratory's Quality Assurance Plan.

Measurement of water-level elevation in wells and total depth of wells will be made using industry-standard measuring devices and procedures as appropriate for conditions. For example, electrical water-level depth probes or steel water level tapes could be employed. Wells, being of varying construction and use, will require varying techniques to determine depth to water and depth to bottom measurements (later to be converted to elevation). Project managers and field professionals will make determinations as to the most appropriate methods employed based on conditions in accordance with JSAI SOP (Appendix C). Industry-standard practices will be employed in determining water elevation to ensure that the data gathered are accurate and precise enough to be useable for analysis.

Method of collection for groundwater samples will be dependent on the type, size, and depth of wells, and may also be dependent on aquifer characteristics. For example, wells that give up three volumes of water in a reasonable amount of time will be sampled by conventional means such as hand bailers or by pumping apparatus. Wells and aquifers that have characteristics that do not allow conventional methods such as low-yield wells, may have to be sampled by micro-purging of the screen interval or by sampling after pumping one well volume. Low-yield wells may be sampled after one well volume is purged. Low-yield wells should be purged at a slow enough rate as to not purge the well dry. If the well does purge dry, it may be sampled when the well recovers sufficiently to yield a sample volume, not to exceed 24 hours after purging. Active windmills will not require purging.

Micro-purging, also known as low-flow purging, is an alternate method for purging wells that is distinctly different from conventional purging methods. Micro-purging can be done in wells where well construction details are known, specifically the screen interval must be known. In micro-purging, a pump or inlet is set close to the middle of the screened interval where water is drawn directly from the screened area of the well, thereby drawing from formation water. As in conventional sampling, indicator parameters (pH, temperature, and conductivity) must have stabilized for three consecutive measurements before samples can be collected. With micropurging the following criteria should be followed:

- Intake point of the pump or tubing is at or near the center of the screen.

- Prior to sampling, return water is clear (or representative of the aquifer) and free of debris, and does not contain major air bubbles in the tubing or other point at which flow can be observed such as clear tubing or a flow-through cell.
- The pumping rate is very low related to the size of the well (for example a 2-inch diameter well should be regulated to less than 1 liter per minute, preferably 0.1 to 0.5 liters per minute).
- Drawdown does not exceed 10 percent of the screen length.
- Micropurging will continue until pH is within 0.2 pH units, temperature is within 1°C, and conductivity is within 10 percent in at least three consecutive

Regardless of method, indicator parameters such as pH, temperature, and conductivity will be used to determine if well purging is adequate to collect samples. In general, well purging will continue until pH is within 0.2 pH units, temperature is within 1 °C, and conductivity is within 10 percent in at least three consecutive measurements.

Aquifer pumping tests are used to determine hydraulic properties of an aquifer by pumping one or more wells for a specified length of time while collecting water table measurements in observation wells at locations at various radii from the pumping well(s). Aquifer characteristics that can be determined by pumping tests include transmissivity, conductivity, coefficient of storage, specific yield, confining layer leakage, and aquifer boundaries such as constant head and no-flow boundaries.

If it is determined that a pumping test is needed, the expertise of hydrogeologists in consultation with Santa Fe Gold, the MMD, NMED, and NMOSE would be needed to design a test based on local conditions, current knowledge of the aquifer, and the goals of the test. Design of a pumping test is beyond the scope of this SAP.

8.2.3.5 Groundwater Analysis

Constituents to be analyzed in groundwater samples include field and inorganic parameters recommended in the MMD Part 6 guidance document for new mines. Table 8-3 contains a list of analytical parameters, analysis methods, NMWQCC standards, and laboratory detection limits. All groundwater samples will be analyzed for dissolved metal concentration.

8.2.3.6 Laboratory and Field Quality Assurance Plans

Baseline water-quality sample collection will be done in accordance with current industry practices and in accordance with the JSAI field Quality Assurance Plan (QAP). A copy of the JSAI field QAP is included in Appendix C. Analysis of water samples will be done in accordance with applicable EPA methods and laboratory QAP.

8.2.3.7 Discussion Supporting the Groundwater Analysis Proposal

The proposed groundwater analysis plan will provide the data needed to characterize baseline conditions for quality and characteristics of Igneous Rock and Sedimentary Rock Aquifers (including the GFZ) identified in the mine permit area and down hydraulic gradient. The historical groundwater data, such as that listed in Tables 8-5 through 8-8, will be used to evaluate current baseline conditions. Establishing current water-level elevation and water-quality conditions down-gradient of the proposed mine facilities will be important for planning and designing proposed mine facilities and establishing the associated groundwater monitoring network.

8.3 Maps Showing Proposed Sampling Locations

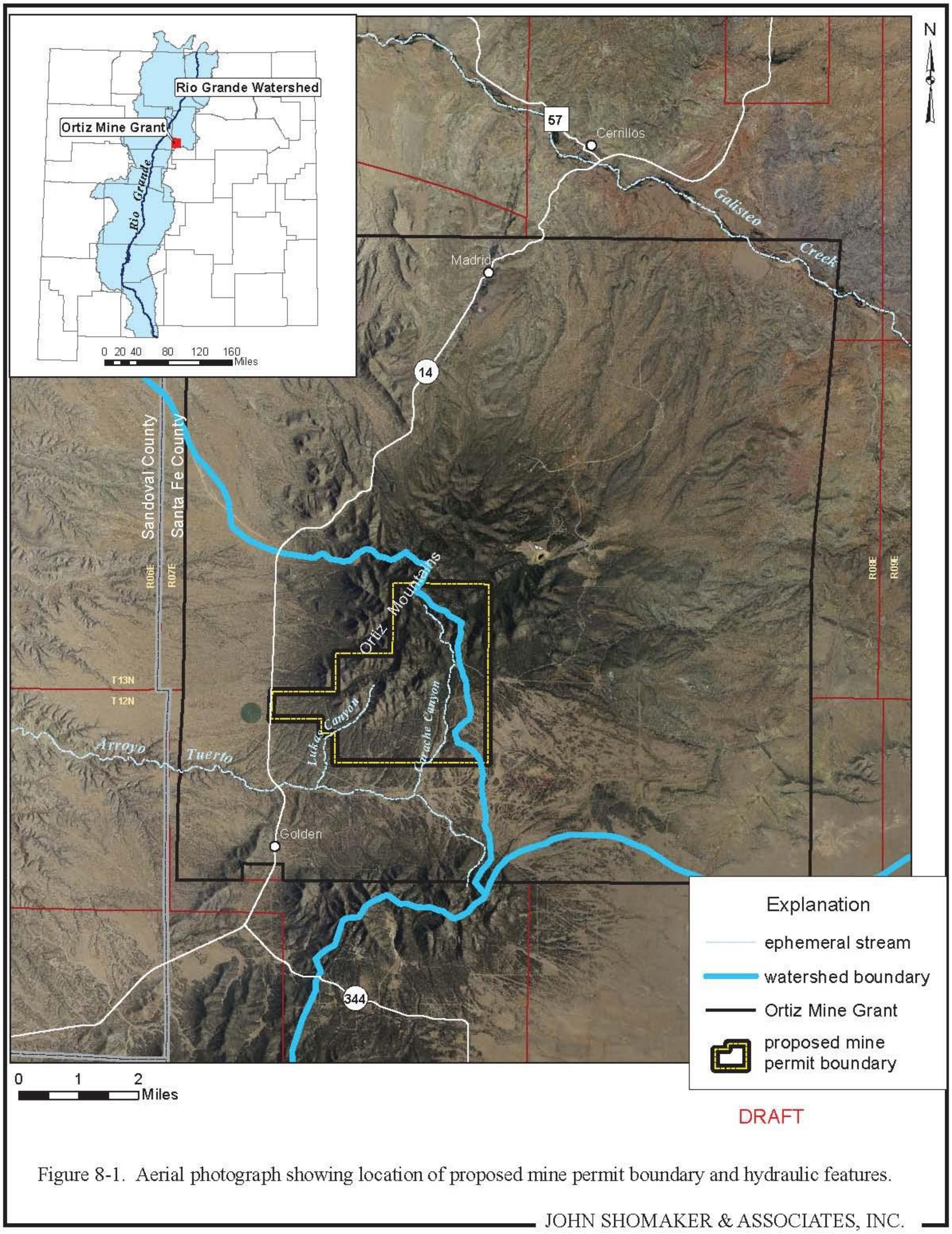


Figure 8-1. Aerial photograph showing location of proposed mine permit boundary and hydraulic features

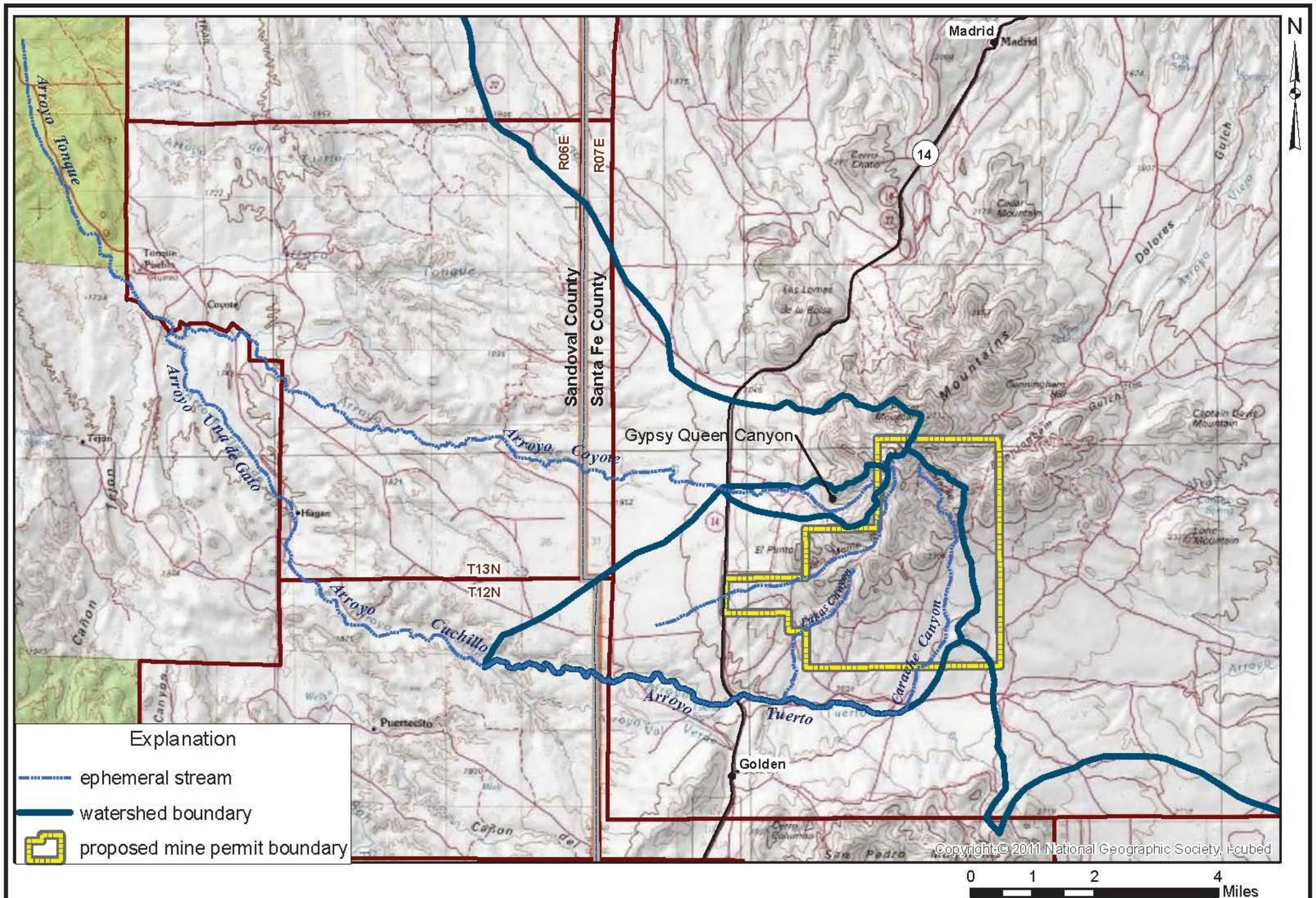


Figure 8-2. Topographic map showing watersheds encompassing the mine permit boundary area and receiving drainages.

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Figure 8-2. Topographic map showing watersheds encompassing the mine permit boundary area and receiving drainages

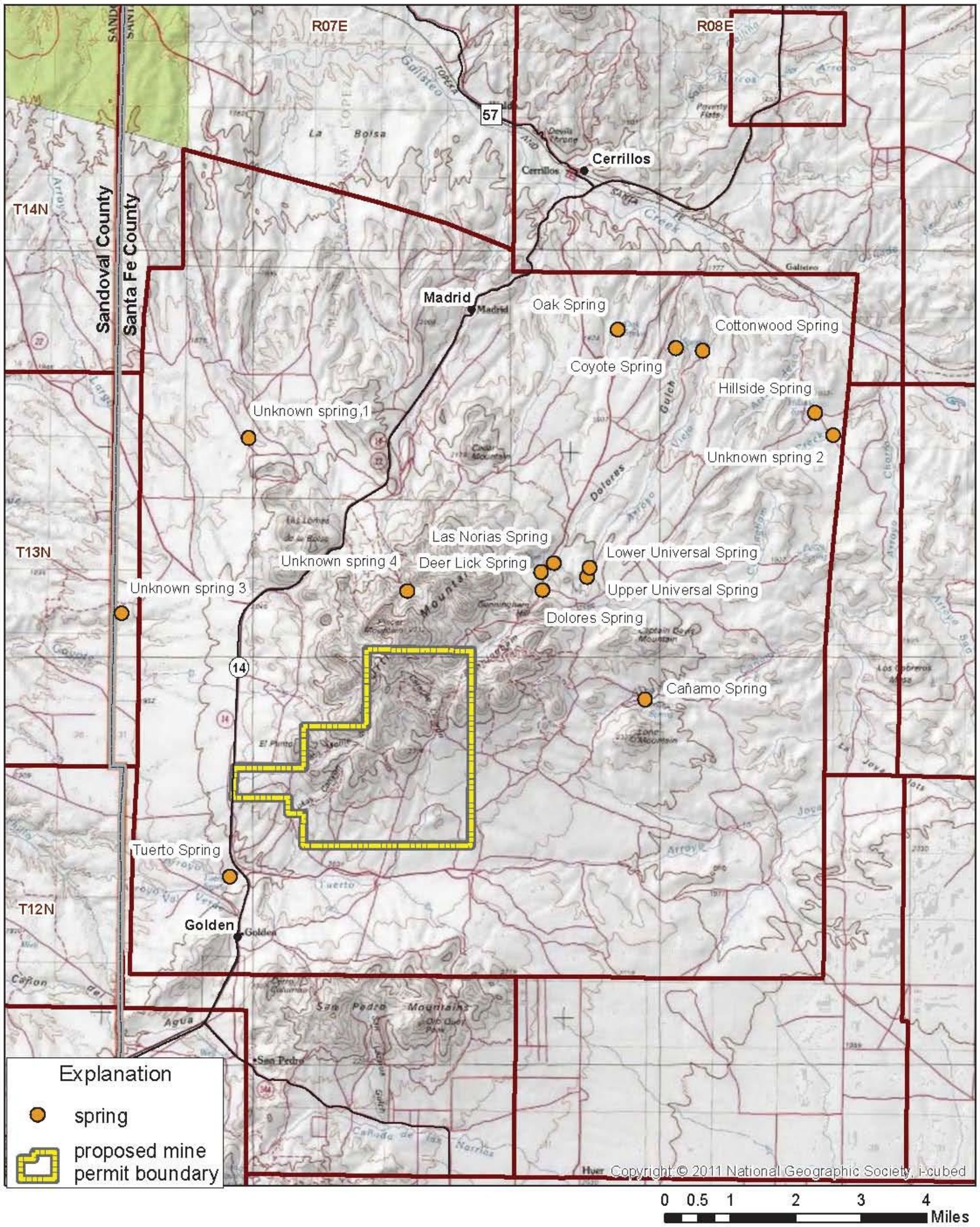

Figure 8-3. Topographic map showing the locations of springs in the Ortiz Mountains vicinity.

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Figure 8-3. Topographic map showing the locations of springs in the Ortiz Mountains vicinity

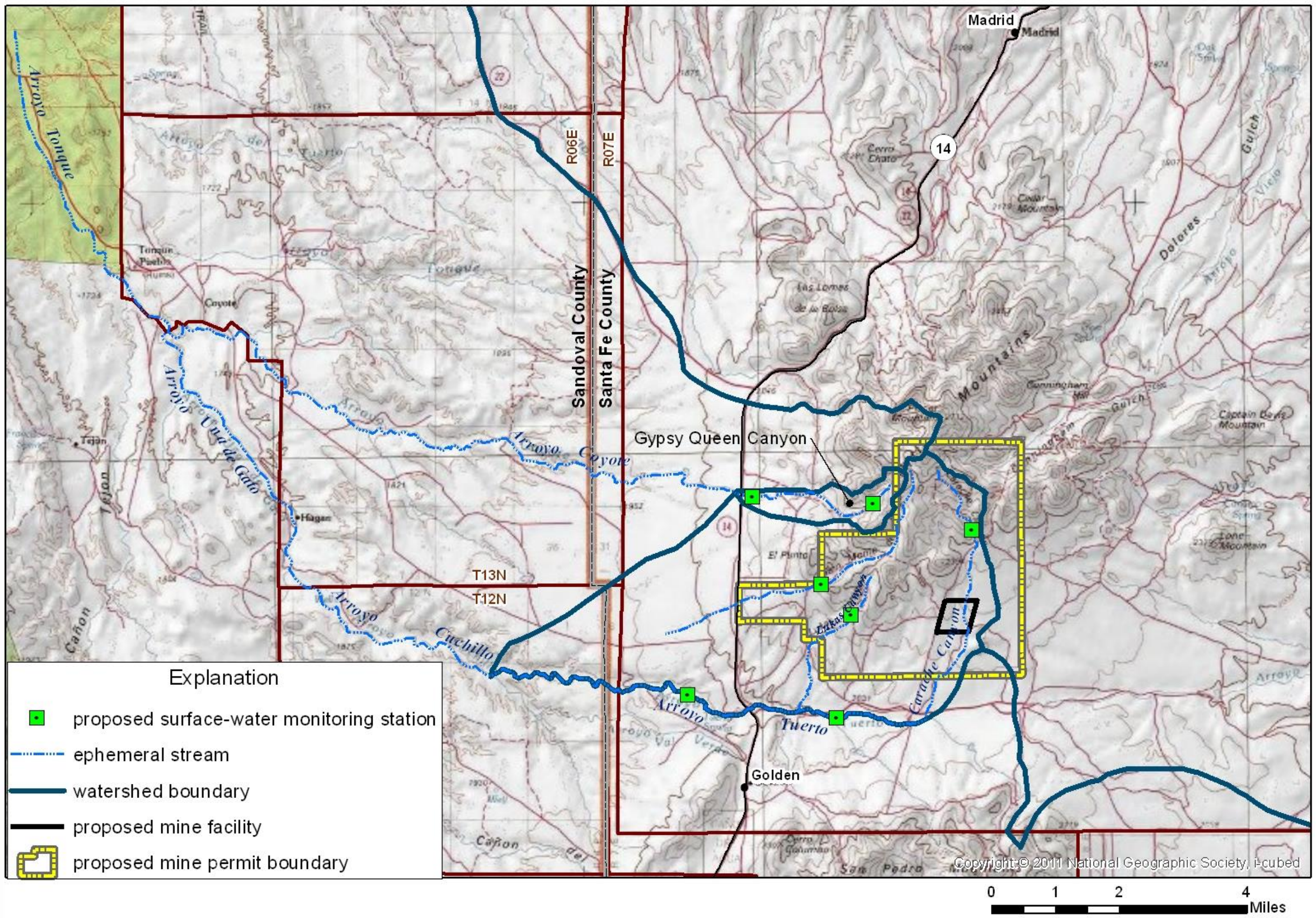

Figure 8-4. Topographic map showing location of proposed mine facilities, primary watersheds, and proposed surface water monitoring stations.

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Figure 8-4. Topographic map showing location of proposed mine facilities, primary watersheds, and proposed surface water monitoring stations

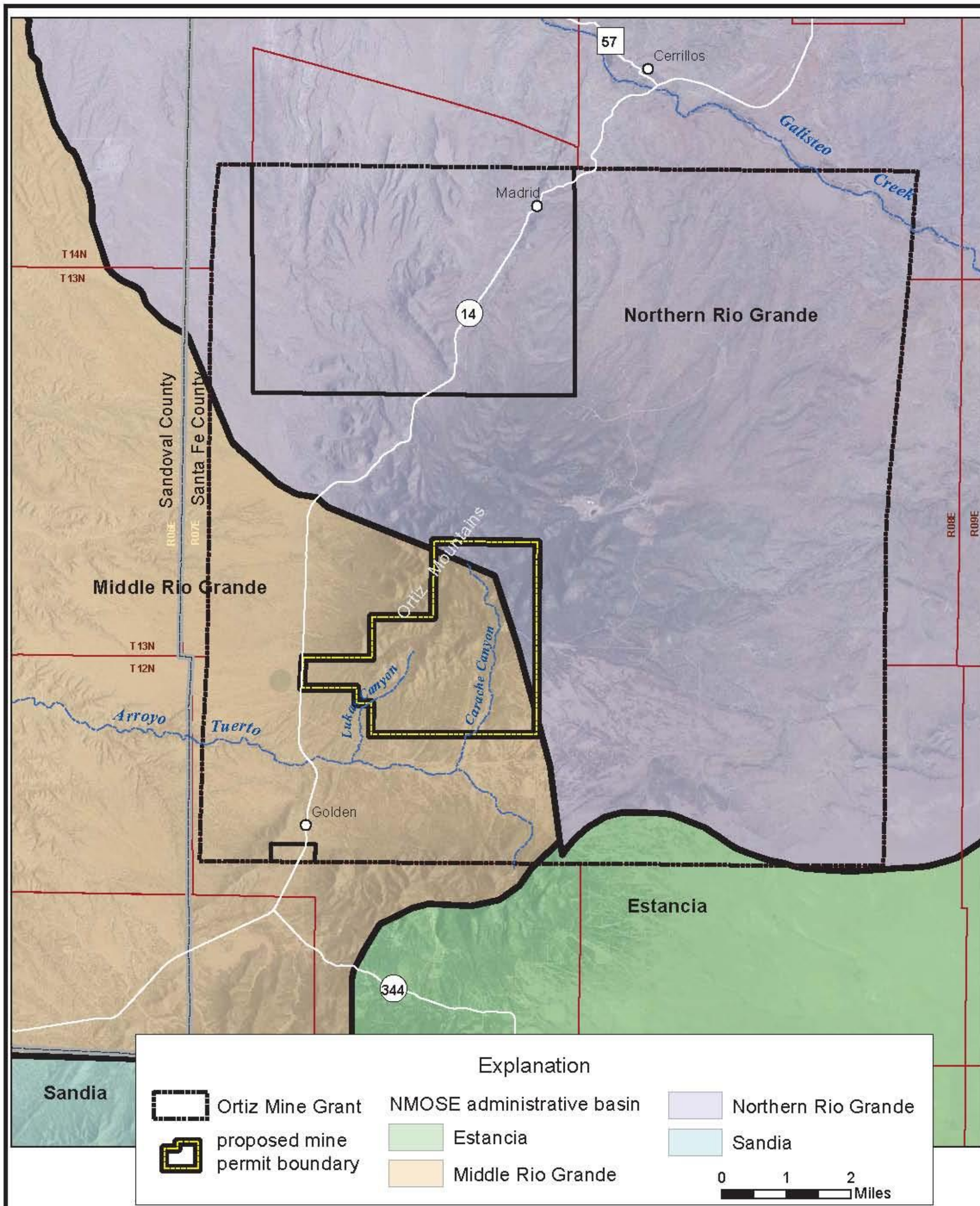

Figure 8-5. Aerial photograph showing proposed mine permit boundary and NMOSE administrative basins.

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Figure 8-5. Aerial photograph showing proposed mine permit boundary and NMOSE administrative basins

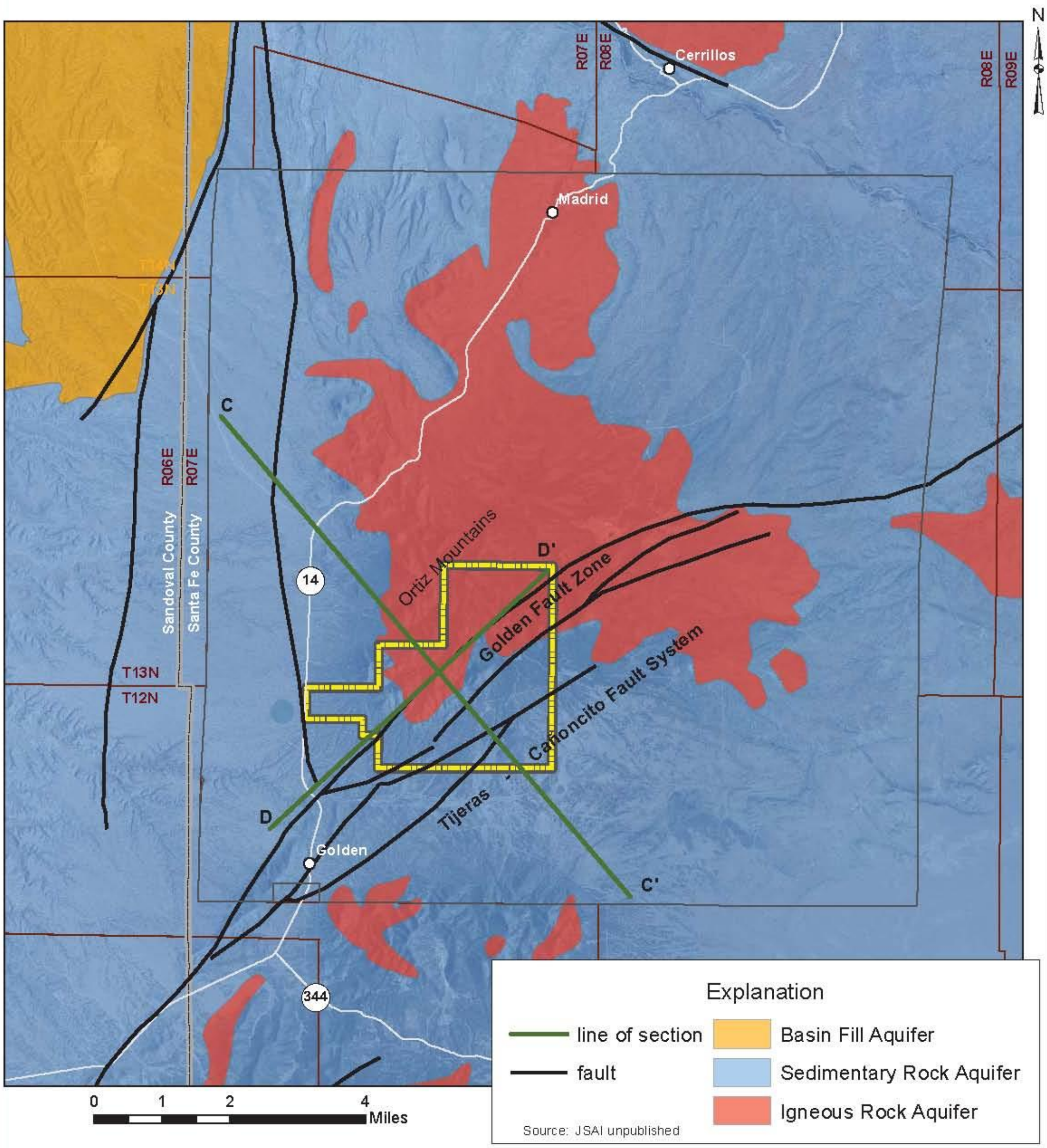

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Figure 8-6. Hydrogeologic map of the Ortiz Mine Grant and vicinity, Santa Fe County, New Mexico.

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Figure 8-6. Hydrogeologic map of the Ortiz Mine Grant and vicinity, Santa Fe County, New Mexico

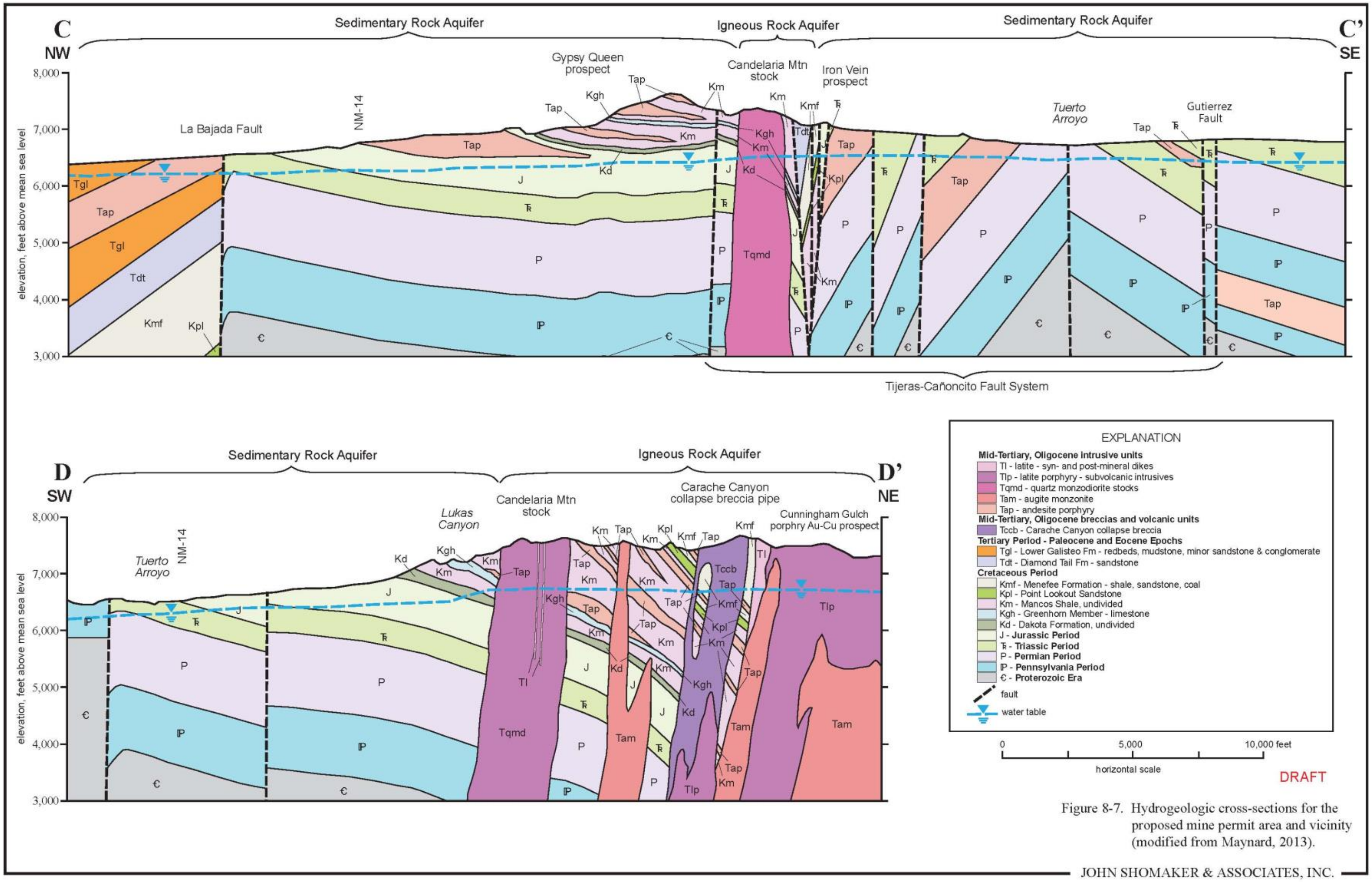

Figure 8-7. Hydrogeologic cross-sections for the proposed mine permit area and vicinity (modified from Maynard, 2013)

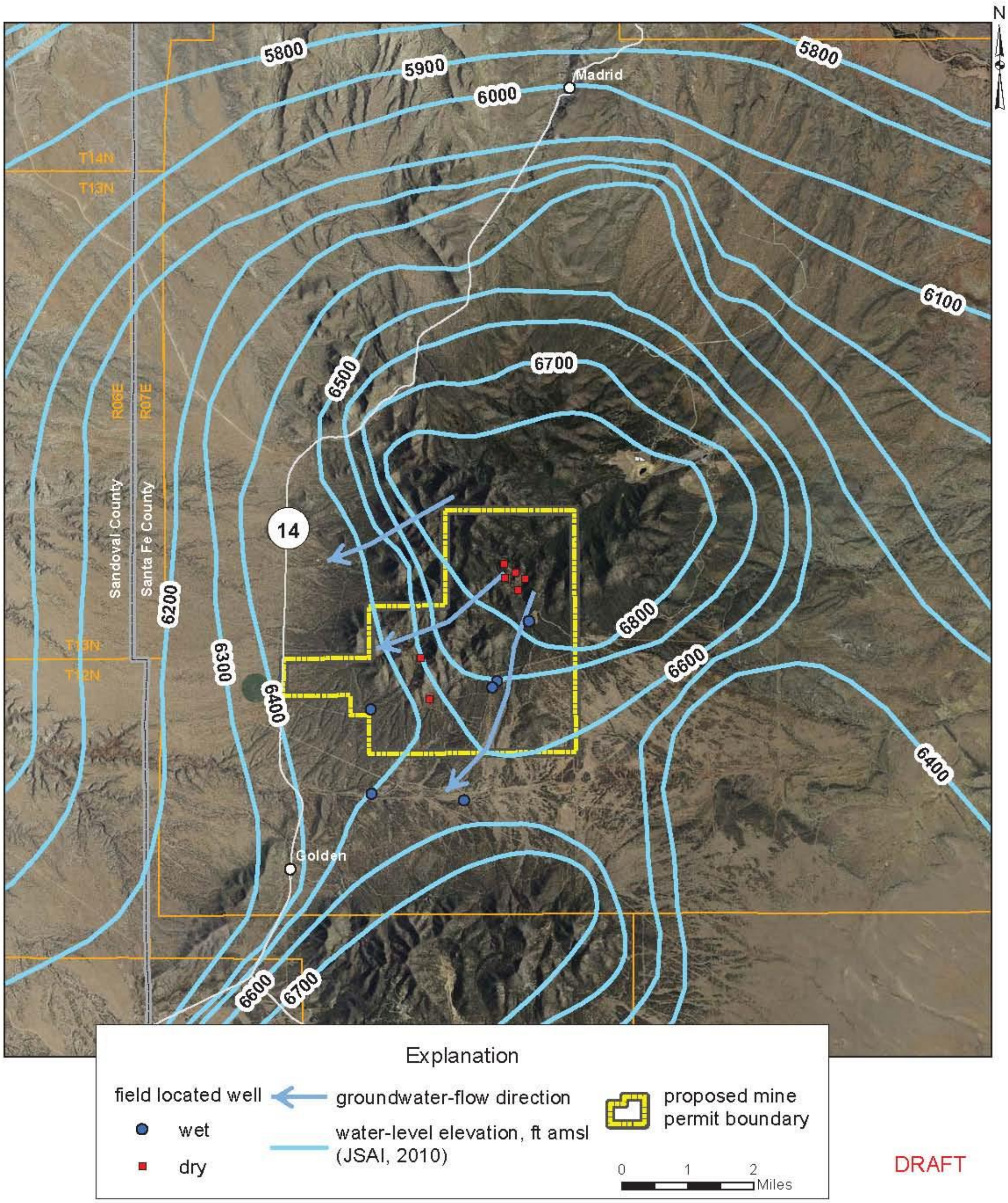

Figure 8-8. Aerial photograph showing regional water-level elevation contours for the Ortiz Mine Grant area and wells surveyed during Spring 2013 field reconnaissance in and around the proposed mine permit area, Santa Fe County, New Mexico.

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Figure 8-8. Aerial photograph showing regional water-level elevation contours for the Ortiz Mine Grant area and wells surveyed during spring 2013 field reconnaissance in and around the proposed mine permit area, Santa Fe County, New Mexico

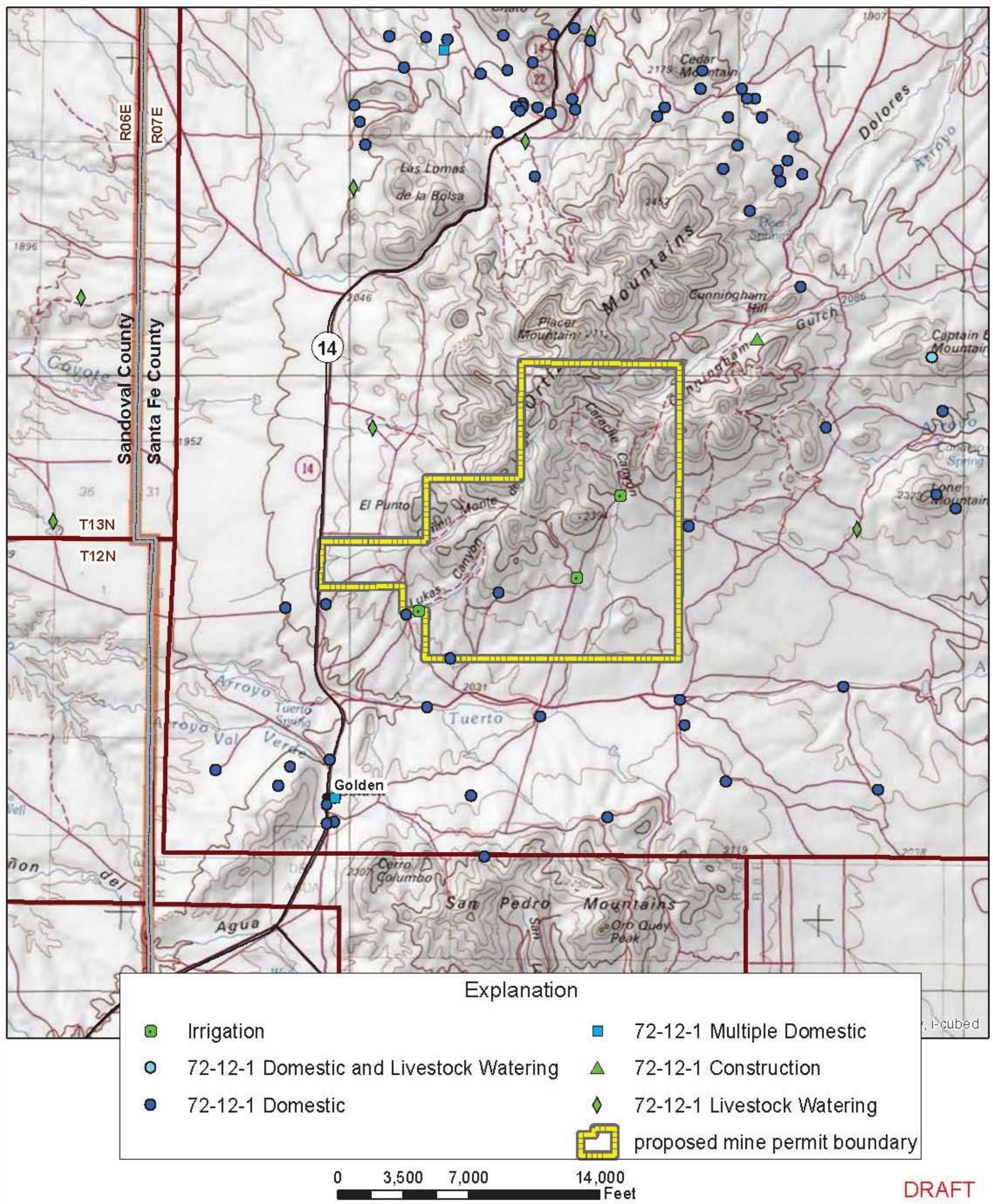

Figure 8-9. Topographic map showing proposed mine permit boundary, and wells in the NMOSE WRRS database within a 5-mile radius of the mine permit area.

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Figure 8-9. Topographic map showing proposed mine permit boundary, and wells in the NMOSE WRRS database within a 5-mile radius of the mine permit area

Figure 8-10.

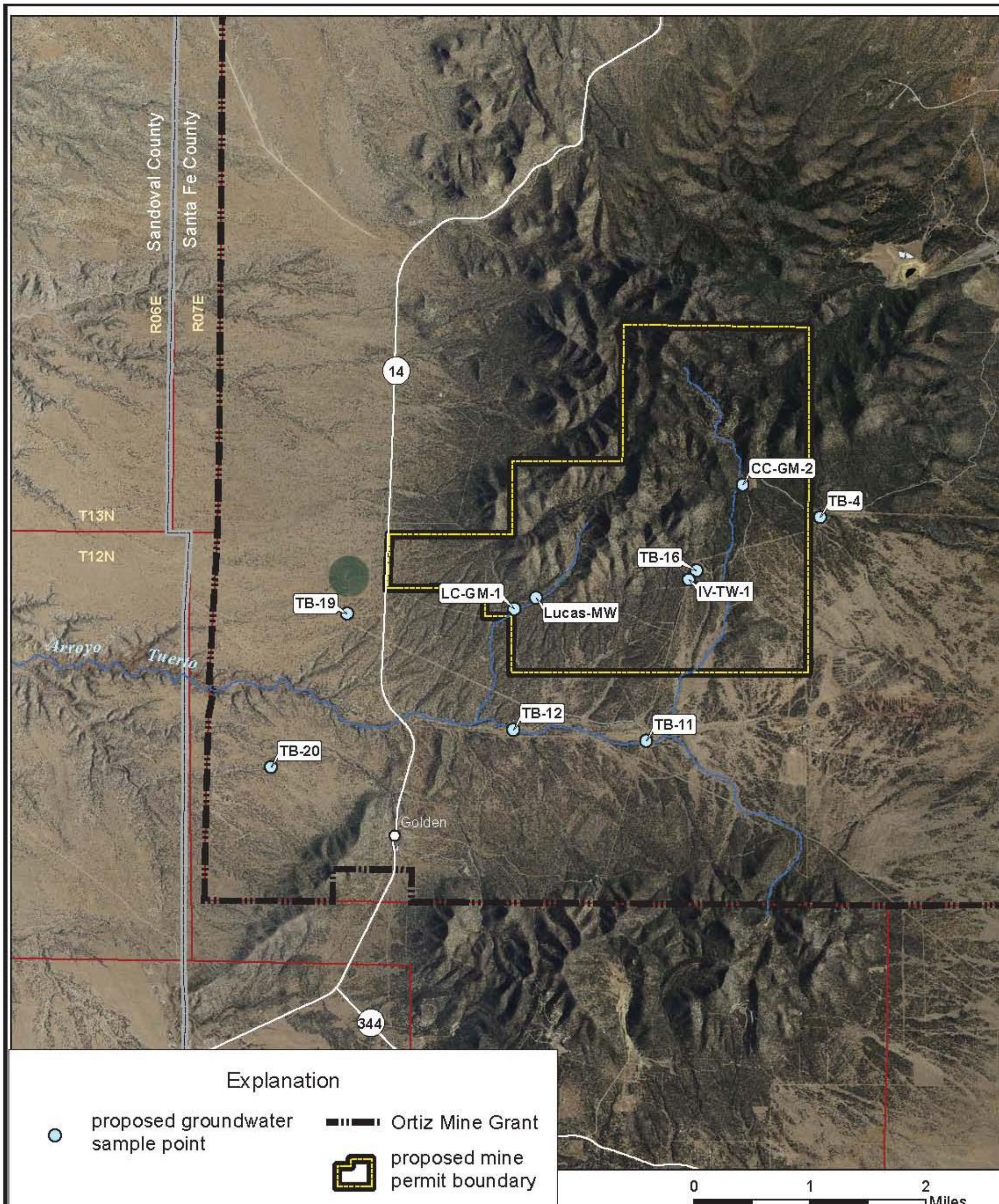

Figure 8-10. Aerial photograph showing location of proposed groundwater sampling points, Ortiz Mine Grant area, Santa Fe County, New Mexico.

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JOHN SHOMAKER & ASSOCIATES, INC.

Figure 8-10. Aerial photograph showing location of proposed groundwater sampling points, Ortiz Mine Grant area, Santa Fe County, New Mexico

9 Historical and Cultural Properties Survey

9.1 Introduction and Background

The majority of the project area was previously surveyed for cultural resources by Mariah Associates, Inc. in three surveys performed in 1988 and 1990 for LAC Minerals, Inc. and the Pegasus Gold Corporation (Evaskovich 1991; Phippen et al. 1989; Phippen et al. 1991). All three of these were Class III archaeological surveys except for one portion of 325 acres that received a Class II survey in consultation with the State Historic Preservation Office (SHPO) based on its location outside the proposed direct impact area and an expectation of low site density. Some of the area surveyed extends outside the current APE; some areas within the APE were not surveyed during these previous efforts.

New Mexico's codes outlining standards for survey and inventory of cultural properties issued by the Historic Preservation Division (4.10.15 NMAC-N) state that even when an area has been previously surveyed, if that survey took place more than 10 years ago, the Historic Preservation Division will review the survey methods used, the completeness of the documentation, and other factors and determine whether a new survey is needed. At the time the three previous surveys were performed, the criterion for which cultural materials were recorded as archaeological sites and isolates was that those materials must have achieved an age of 75 years or more. In addition, a survey was considered "intensive" (Class III) if the crew members were spaced at intervals of 25 meters (m), with that interval either narrow or wider depending on conditions. The current criterion for identifying which cultural materials to record is now 50 years of age, and the standard survey interval is now 15 m except where landforms and/or ground visibility indicate a narrower or wider interval is appropriate.

9.2 Introduction and Background

By obtaining knowledge of the local cultural history prior to conducting surveys, cultural resource specialists are better able to identify and interpret findings. Understanding the material and spatial correlates of different culture groups through time ensures that cultural items are identified during survey and then interpreted in the proper context. The proposed project falls within the area covered by the Galisteo Basin Archaeological Sites Protection Act and the associated National Register of Historic Places Multiple Property Documentation Form which, as of this writing, is in draft form awaiting concurrence by the State Historic Preservation Office. That document has identified seven historic contexts associated with the Galisteo Basin and which are applicable to the project area:

1) Early Human Use: Archaic Period (5500 B.C. to A.D. 600)
2) Ancestral Puebloan Settlement: Developmental Period (A.D. 600-1200)
3) Ancestral Puebloan Coalescent Farming Communities: Coalition Period (A.D. 1200 to 1325)
4) Ancestral Puebloan Expansion, Aggregation, and Florescence: Classic Period (A.D. 1325-1550)
5) Spanish Entradas, Missionization, Colonization, Pueblo Revolt, and Reconquest (A.D. 1550-1700)
6) Pueblo Settlement Reorganization and Euroamerican Settlement, Mining, and Ranching (1700-1880)
7) Arrival of the Railroad, Euroamerican Land Use, Archaeological Research, and Descendant Communities (1880 to present)

The results of the three archaeological surveys performed in the project area previously are good indicators as to the numbers and types of sites that are present. The first was a survey of approximately 1900 acres conducted in 1988 (Phippen et al. 1989). The survey located five archaeological sites, three of which were historic mining-related. Another 5000 acres were surveyed in 1990 (Phippen et al. 1991). The project located 54 archaeological sites. Of these, the Lukas Mill site and the Gypsy Queen Mine site were considered to be of particular significance, as was LA 77468, a possible Paleoindian site, and LA 77528, a possible eagle trap. A supplemental 600 acres was surveyed in 1990 (Evaskovich 1991). The survey located 18 sites. Of these, the Benton Mine, the Old Ortiz Mine, and the townsite of Dolores were judged to be of special significance.

The sites found during the three previous surveys indicate that Paleoindian sites are relatively scarce in the general region. Cordell (1979: 6) suspects that many Paleoindian sites in the area are overlain with later occupations or are deeply buried, making them invisible to researchers employing traditional pedestrian survey methods. Several Archaic sites were found, as were some Ancestral Puebloan sites (mainly from the Pueblo IV period that is item 4 in the list above). Many historic sites were found, most dating to 1870 and beyond and associated with mining in the area.

The previously documented sites will likely comprise the majority of the cultural resources identified during the current investigation, but it is probable that undiscovered sites are present in those portions of the project area that were not previously surveyed, and a few new sites may be discovered in the previously surveyed areas. It is expected that any new sites will be consistent in type to those previously recorded.

9.3 Sampling Objectives

Because the project area entails land modification activities, the proposed activity is subject to Section 106 of the National Historic Preservation Act (NHPA, P.L. 89-665, as amended). The NHPA requires consideration of the effects that a proposed undertaking may have on historic properties as defined by this legislation.

The purpose of the cultural resource investigation will be to locate and assess all cultural resources and historic properties within the area of potential effects (APE). The APE—and any potential sampling strategy—will be defined in consultation with the SHPO. However, surveys conducted for land-modifying undertakings are typically intensive (100 percent pedestrian coverage) and sampling is not a common strategy. Standard transect intervals vary between 5 and 15 m (16 and 49 ft). The diverse and sometimes precipitous topography in the project area poses some challenges to the survey design. Where slopes are steeper than 30°, the strategy will be to inspect any associated flats or bench areas as well as any associated hilltops, ridge tops, saddles, and drainage bottoms with the same survey intervals as the rest of the project area. Steep slopes will be less intensively inspected, but will be examined to the extent the safety of crew members permits. As with the definition of the APE, the width of the proposed survey intervals will be determined in consultation with the SHPO.

9.4 Sampling Frequency

The intensive pedestrian survey of the APE is anticipated to be limited to a single-episode field investigation and recording effort. Transects may vary, but are likely to be 15 m (49 ft) in width for the entire APE (except where steep slopes pose safety concerns as outlined above). This technique is the standard for all cultural resource investigations on federal property and on lands administered by the State of New Mexico.

9.5 List of Data to be Collected

Prior to conducting the survey, cultural resource specialists will complete a pre-field records review of the New Mexico Cultural Resources Information System (NMCRIS) database to obtain information about previously recorded archaeological sites and surveys in the project area and vicinity. In addition, current listings of the NRHP and the New Mexico State Register of Cultural Properties (NMSRCP) will be consulted to determine the known presence of any listed cultural properties or districts within and in the vicinity of the project area.

The types of properties or data that may be encountered during the survey include, but are not limited to, archaeological sites, historical cultural properties (historical period buildings, structures, or objects over 50 years old), historical districts, and isolated occurrences (IOs). Archaeological sites will be identified in accordance with current NMAC 14.10.15 guidelines that define a site as:

> …a location where there exists material evidence of the past life and culture of human beings in the state. A significant archaeological site typically is 50 or more years old. Examples of archaeological sites include without limitation campsites, pueblos, homesteads, artifact scatters, resource procurement or processing areas, agricultural fields, locales with one or more features in association with other cultural materials, and locales that have the potential for subsurface features or cultural deposits.

Cultural materials that do not meet the definition of a site will be recorded as IOs. The same guidelines define an IO as "a single object or artifact or a few artifacts greater than 50 or more years old that lack clear association. Examples of isolates include a single flake, projectile point, potsherd, sherds from a single broken pottery vessel, pieces of glass from a single bottle or a single feature that lacks integrity."

All sites will be recorded on current Laboratory of Anthropology (LA) Site Record forms. Information for all fields on the form will be gathered with the exception of the fields for SHPO use. Previously recorded sites will be updated using the same form. Cultural and temporal affiliations will be assigned to sites with diagnostic artifacts and/or features on the basis of widely accepted type descriptions.

Complete projectile points and point fragments will be sketched in the field for later typological classification, or to confirm in-field classification. Ceramics will be analyzed in the field with the use of field manuals providing ceramic type descriptions and completed ceramic analysis forms that include entries for typological classification and for various technological and design attributes for artifacts that cannot be confidently classified as to type. Historic artifacts with embossing or other information useful for establishing temporal affiliation or of other research value will also be sketched and/or photographed. Unless otherwise directed by the SHPO, no artifacts or other cultural materials will be collected during the proposed investigation. All data will be recorded in the field and all cultural materials will be left in place.

UTM coordinates will be collected for features, unique and temporally diagnostic artifacts, site datums, boundaries, and so forth. Site overview, features, and unique and temporally diagnostic artifacts will be photographed. Scaled site sketch maps will be created in the field with the assistance of GPS units and then rendered using Adobe Illustrator. Site maps will include the LA site number; the site boundaries and the datum location; a north arrow, scale, and legend; feature and artifact locations; the locations of temporally diagnostic artifacts; any roads and environmental features; photograph points; and, if applicable, the APE boundary or other spatial information regarding the proposed undertaking.

Isolates will be documented with a description of the artifact(s) or feature type, measurements, frequencies, and UTM coordinates. Temporally diagnostic artifacts will be sketched and/or photographed.

In-use historical buildings, structures, and objects will be recorded using the New Mexico Historic Cultural Properties Inventory (HCPI) form. Each building or structure will be photographed and UTM coordinates collected. Form 1 of the HCPI will be completed for all historical buildings. Form 2 will be completed only for historical buildings that are recommended as being eligible to the NRHP. Acequias will be recorded on the Historic Water Delivery System Inventory Form. These resources will be photographed and UTM coordinates collected.

9.6 Methods of Collection

The survey will be conducted by walking parallel transects spaced 15 m (50 ft) apart throughout the entire survey corridor (except on very steep slopes as specified above). Archaeological sites will be documented on the state's Laboratory of Anthropology (LA) site forms and supplementary forms as described above. UTM coordinates for features, unique and temporally diagnostic artifacts, site datums, boundaries, and so forth will be collected using a GPS with sub-meter accuracy with data dictionary capability. Once collected, the GIS data will be differentially corrected and used to generate accurate site maps and site location maps using ArcMap software. Site sketch maps will be created in the field with the assistance of GPS units and then rendered using Adobe Illustrator. Photographs will be taken with high-resolution digital cameras (8 mpx or better).

9.7 Parameters to be Analyzed

All cultural resources encountered during the investigation will be evaluated in terms of their eligibility for listing in the NRHP, using the implementing regulations provided in 36 CFR Part 60.4 and the guidance in the National Park Service (NPS) National Register Bulletin 15 on applying the NRHP criteria and Bulletin 36 on evaluating and registering archaeological properties . Furthermore, project-specific treatment recommendations will be provided for all NRHP-eligible cultural resources that may be subject to adverse effects from the proposed undertaking.

The APE will be evaluated for potential archaeological or historic districts and/or cultural landscapes before, during, and after fieldwork using standards outlined in the New Mexico Register (Volume XVI, Issue Number 15, August 15, 2005) and the National Register Bulletin 30 on evaluating and registering rural historic landscapes. Other materials used to guide the identification of districts and landscapes include NPS Preservation Brief 36 (Birnbaum 1994) on the protection and management of cultural landscapes. This document defines "landscape," as a site or a district (36 CFR 60.2) in contrast to terms related to eligibility for the NRHP.

As suggested by the NPS in Bulletin 30, researchers define any potential landscape through their choices of historical contexts, period or periods of significance, potential boundaries, and contributing or non-contributing elements. Defined landscapes are more difficult to characterize than buildings or structures with readily definable physical features and boundaries. However, many landscapes do have tangible features and landscape characteristics resulting from human use.

Traditional cultural properties will be evaluated following guidance provided in National Register Bulletin 38 on evaluating and documenting traditional cultural properties. Human remains and associated funerary objects will be treated in accordance with the Native American Graves Protection and Repatriation Act. All assessments will be conducted in close consultation with the SHPO and other appropriate consulting parties.

In most cases, the treatment recommendations for cultural resources will include the following statement:

> It is recommended that all project-related activities avoid any cultural resources determined to be eligible for inclusion in the NRHP. If total avoidance is feasible, subject to consultation and comment, the proposed undertaking will have no effect on the documented cultural resources. If complete avoidance is not possible, but the undertaking only affects portions of the sites that lack integrity, the proposed undertaking should have no adverse effect on the qualities that qualify the resources for inclusion in the NRHP. However, if avoidance of potentially intact portions of the site areas is not feasible, then one of two actions is recommended to minimize and mitigate potential adverse effects: (1) The project proponent should prepare a testing and data recovery plan per the New Mexico Administrative Code (NMAC) 4.10.8 and to the standards within NMAC 4.10.16, or (2) the project proponent should prepare a monitoring plan prior to construction per NMAC 4.10.17.11. Either plan should be implemented per agency standards, the NMAC, and in consultation with the SHPO and the Cultural Properties Review Committee (if warranted).

9.8 Maps Showing Proposed Sampling Locations

Figure 1-1 and Figure 1-2 illustrate the extent of the area that could be affected under the proposed project and is the area recommended as the APE and, by extension, the proposed archaeological survey.

9.9 Laboratory and field Quality Assurance Plans

Accurate work and timely deliverables will be provided. The fieldwork and reporting will be performed in compliance with all aspects of the NMAC, including NMAC 4.10.15.

9.10 Discussion Supporting the Proposed Sampling Plan

As stated above, sampling is not considered a standard strategy for cultural resource investigations in New Mexico. The entire APE will be surveyed using a standard 15-m (49-ft) transect interval, which is otherwise defined as an intensive Class III survey except in areas where the terrain poses a safety hazard. Any modification to the APE, the survey parameters, or the data collection efforts will be the result of consultation with the SHPO.

10 Historic and Present Land Use

The Santa Fe Gold Corporation (SFEG) is currently in possession of the mineral lease for a 42,297-acre expanse within the Ortiz Mine Grant located south of the City of Santa Fe in Santa Fe County, New Mexico. Lone Mountain Ranch, LLC and Rancho de Chavez currently have surface ownership of the Ortiz Land Grant within the proposed permit area (Figure 1-1. Proposed Permit Area).

10.1 Mining

The Ortiz Mine Grant is one of the oldest mining areas in New Mexico and in the United States. The prospecting and mining of gold and silver in the Ortiz area dates to the arrival of the first European settlers in 1598. Significant gold production from Ortiz placer deposits dates to 1821. By 1832, several veins and low-grade gold deposits had been discovered. The Ortiz Mine Grant legal status derives from the granting of surface and mineral rights of an approximately 16 km by 16 km (10-mi by 10-mi) tract to Francisco Ortiz by the First Alcalde of the City of Santa Fe in 1832 (Maynard 2013). By the early 1840's, mining at the small underground Ortiz Mine had ceased. At that time the area was under the control of Mexico.

In 1845, under the Treaty of Guadalupe Hidalgo, Mexico ceded much of what is now California, Arizona, and New Mexico to the United States. Under the treaty the United States agreed to honor the Land Grant titles. In 1860 the title to the Ortiz Mine Grant was confirmed by the United States and the owners received fee simple title to the surface and minerals. In the late 1800's approximately 15,000 acres in the northwest quadrant of the grant was deeded to Cerillos Coal and Iron Company. That area is often referred to as the Madrid Exception.

Because of title issues and business failures, the Ortiz Mine Grant eventually ended up in the hands of the United States government, and in 1943, the grant was sold for grazing purposes to the Ortiz Cooperative Livestock Association, which was funded by the United States Farm Security Administration. However, the association never made any of the mortgage payments, and in 1946 the grant was sold at auction to Mrs. George Potter of Joplin, Missouri. The Potters sold the surface rights of the southern 54,000 acres to Howell Gage, W. L. McDonald, and Frank Young in 1947. The Potters were experienced miners and retained the mineral rights; in 1959, the mineral-interest owners and associates formed Ortiz Mines, Inc. for the purpose of promoting and marketing the mineral estate. Consolidated Gold Fields developed the first mine on the Cunningham Hill deposit on the eastern half of the Ortiz Land Grant, producing approximately 250,000 ounces of gold between 1979 and 1986 (Maynard 2013). Total pre-1979 mine production has been estimated at about 100,000 ounces of gold.

From 1972 through the early 1990's, several companies operating under lease with Ortiz Mines, Inc. carried out exploration and pre-development activities in the southern portion of the Grant. These companies included Conoco, Inc., LAC Minerals (USA), Inc. and the LAC-Pegasus Joint Venture. The LAC-Pegasus Joint Venture carried out the majority of the work in the western portion of the Grant, from 1989-1992. The Joint Venture focused on two deposits in the southwestern part of the Grant, namely the Carache Canyon ("Carache") and Lukas Canyon ("Lukas") deposits. These two deposits were the subject of 386,000 feet of core and reverse-circulation drilling, metallurgical testing and pre-feasibility studies carried out by the LAC-Pegasus Joint Venture and by consulting firms and contractors engaged by the Joint Venture.

In 1989, the LAC-Pegasus Joint Venture started a decline adit into the Carache deposit for the purpose of bulk sampling and to provide drilling access for shallow and deep exploration targets. However, after advancing 1,719 feet the decline was halted due to a temporary water inflow coupled with regulatory and permitting issues. In the face of a declining gold price, mining development of the Carache or Lukas deposits did not proceed, and the project ultimately was cancelled and the lease returned to Ortiz Mines, Inc. Subsequently, no additional exploration was carried out and the property remained dormant until SFG leased it in August 2004.

Potter/Ortiz, LLC holds title to four patented mine claims (mineral and surface estates) within the Ortiz Mine Grant: Black Prince, Illinois, Ohio, and Lukas Millsite (Figure 1-1).

10.1.1 Reclamation of previous mining activities

Exploration roads, drill pads, pits and a decline area (approximately 9 acres) impacted during the LAC/Pegasus property evaluation period of 1989-1992 were reclaimed to industry standards. Reclamation activities consisted of backfilling, seed bed preparation, and seeding. Most reclaimed areas have moderate to good revegetation success. Several exploration roads are still evident and remain passable with four wheel drive vehicles.

10.2 Ranching

The southern portion of the Ortiz Mine Grant remains in a few large ranch tracts such as the Rancho de Chavez (formerly Ortiz Mountain Ranch, purchased by Steven Chavez 2011) and the Lone Mountain Ranch (Baxter 2004). Howell Gage operated the latter until the 1950s and named the ranch after the Lone Mountain peak that sits in the northeast portion. Mr. Gage was the warden at the state penitentiary in Santa Fe, which is reflected in the use of hollow tile blocks manufactured at the prison and used to construct some of the ranch buildings and fences. When Mr. Gage resigned as warden in 1950 and moved from Santa Fe, he leased the ranch and used it to raise sheep. In the late 1950s, Howard Glenn of Fort Morgan, Colorado purchased the ranch; it is reflected on the 1962 USGS topographic map as the “Glenn Ranch”. In 1965, Glen Lloyd, a prominent Chicago attorney and Chairman of the Board of Trustees of the University of Chicago, and his wife, Marion Lloyd, purchased Lone Mountain Ranch. When Mr. Lloyd died in 1975, Marion continued to run the ranch and today it remains in the Lloyd family, and has been operated by Robert and Mary Lloyd Estrin since the mid-1990s.

10.3 Farming

Lone Mountain Ranch currently grows an annual cattle food crop from an irrigated field of approximately 90 acres located just west of NM 14 (Figure 1-2. Proposed Mining Activities).

10.4 Conservation

The Ortiz Mountains Educational Preserve (OMEP) comprises 1,350 acres in the upper reaches of the Ortiz Mountains north of the proposed project area (Figure 1-1). It is owned by Santa Fe County and managed by Santa Fe Botanical Garden (SFBG).

10.5 List of Data to be Collected

- Land Planning and Regional Land Use
- Structures on Site
- Access, Rights of Way, and Water Rights
- Environmental Liabilities and Permits

10.6 Methods of Collection

- Review of county assessors records, interviews, BLM land-use maps, etc
- Records review, historic aerial photo review, etc.

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Appendix A - Documents evidencing the applicant's right to enter the proposed permit area and conduct mining and reclamation

Santa Fe Gold/Lone Mountain Ranch Access Agreement

A Memorandum of Understanding (MOU) was executed between Santa Fe Gold and Lone Mountain Ranch, LLC on January 15, 2013. The MOU grants Santa Fe Gold access to the Lone Mountain Ranch surface estate for the purpose of collecting baseline data that will comprise the basis for the Baseline Data Report (BDR) required by the NM MMD as part of a new mine permit application.

Appendix B - Statement of all mining operations with the United States owned, operated or directly controlled by the applicant, owner or operator

Santa Fe Gold Mining Operations

Santa Fe Gold Corporation currently operates two facilities in the US: the Summit Mine in Grant County and the Lordsburg Mill in Hidalgo County.

Appendix C – Quality Assurance Plans

GL Environmental, Inc.
Quality Assurance System Manual

September 14, 2009
Revision 2

GL Environmental, Inc.
P.O. Box 1746
Las Vegas, NM 87701
Phone: (505) 454-0830
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Subject: Quality Assurance System Manual

Revision by: ____ Date: __________________________
Matthew Lane, Project manager

Approved by: ____ Date: __________________________
Jerusha Rawlings, QA Manager

Approved by: ____ Date: __________________________
Denise Gallegos, Principal Investigator

1.0 Purpose

This manual establishes an all-encompassing Quality system for GL Environmental Inc.

2.0 Scope

All procedures and documents used during GL Environmental Inc.'s services and operation.

3.0 Definitions

- **Principal Investigators –** Duties include management of the corporation and contracts. The PI is also a Principal Professional, i.e. directly responsible for environmental consulting and/or permitting on some project elements.

- **QA Manager –** Ensures that the QA program is fully implemented, including control of the QA manual and standard operating procedures, identifying and documenting conditions adverse to quality, maintaining personnel training files, and assuring that data validation and reporting are performed in accordance with applicable procedures.

- **Quality Policy –** a statement of the intent and commitment level expected by all GL Environmental, Inc. employees.

- **Regulatory requirement –** any governmental rule or law that has bearing on GL Environmental, Inc. activities associated with this document and the Quality Policy.

4.0 References

Any and all regulatory requirements and key client requirements

5.0 Quality Policy

GL Environmental, Inc. is committed to providing services of the highest quality. As a contracted environmental consulting company, it is our policy to meet or exceed all customer and regulatory expectations. Our commitment to excellence is employed throughout our company as well as by our contractors.

6.0 Quality System

The GL Environmental Quality System is described in the text of this Quality Assurance Manual and supporting documents that correspond to key elements in the Quality Assurance Manual. These documents establish procedures for quality-related activities throughout the company and ensure compliance with regulatory requirements and the GL Environmental, Inc. Quality Policy.

The Quality System provides the QA manager with independence from other company operations regarding the level of compliance with the Quality Policy and provides an instrument for GL Environmental, Inc. to produce superior products and services. All processes and equipment used in the services provided by GL Environmental, Inc. are subject to this policy.

7.0 Elements of the Quality System

7.1 Principal Investigators

Principal Investigators are the most senior employees at GL Environmental, Inc. and provide guidance for company operations. The ultimate responsibility for quality rests with the Principal Investigators. The QA manager reports directly to the principal investigators for Quality System-related activities. The Principal Investigators ensure sufficient emphasis and resources are allocated to the Quality System to ensure that all objectives of the system are established and maintained.

7.2 Organization

GL Environmental Inc.'s organizational structure facilitates the establishment of defined authority and responsibility within the management system. This structure encourages a high level of performance for all employees. The GL Environmental, Inc. organizational structure is defined in the GL Quality Assurance System Implementation Plan.

7.3 Responsibility and Authority

The project manager and the QA manager have the responsibility to identify and direct activities to achieve systematic compliance with the Quality System throughout the organization. The QA manager has the definitive authority to advance the Quality System objectives for standard company operations, and all GL Environmental, Inc. employees have the responsibility to promote the Quality Policy within the scope of their duties.

7.4 Documentation / Procedural Structure

The Quality System provides the necessary procedural structure to ensure the Quality Policy is met by developing, documenting, and implementing methods that will fulfill required tasks while achieving the greatest precision and accuracy. The methods include anticipation of issues associated with a task, procedures to accomplish the task, verifying the results of the action in association with the method, and re-adjusting the procedure if needed.

See the GL Quality Assurance System Implementation Plan.

7.5 Control of Measuring Equipment

Measuring and monitoring equipment used that are subject to the Quality Policy are controlled. The use of precise reliable equipment is made available through calibration status records that are maintained as part of the Quality System (See GL Quality Assurance System Implementation Plan).

7.6 Document Control and Record Retention

GL incorporates procedures to ensure that documents generated for reference are initiated, changed, and controlled to ensure use of only active and accurate documents. Documents are maintained for a period of five (5) years. These records are made available to client's representatives and may be maintained for longer or shorter periods when agreed upon contractually.

7.7 Quality of Purchased Items and Services

Any vendors that provide equipment or services procured by GL Environmental, Inc that are subject to the Quality Policy are obligated to adhere to, at a minimum, GL's requirements defined in the GL Quality Assurance System Implementation Plan as well as to any additional specifications required by our clients.

7.8 Inspections and Audits

GL performs periodic inspections of all elements of its QA program to verify conformance of each item or activity to specified requirements. Inspections results are maintained as part of GL Environmental Inc.'s Document Control (See GL Quality Assurance System Implementation Plan). Audits will be performed on selected vendors through the use of a qualified independent, third-party if required or requested to confirm that all components of GL Environmental, Inc.'s services comply with our Quality Policy.

7.9 Corrective and Preventative Action

The systematic and integrated deployment of effective solutions that eliminate the root cause and prevent the production of substandard products is the ultimate outcome of corrective action activities. Documented procedures and records associated with corrective actions are developed and maintained by the Quality System. All potential or actual non-conformances from all sources (internal and external) are processed through the Corrective Action Report procedure (See the GL Quality Assurance System Implementation Plan). This procedure provides a vehicle to analyze and implement solutions that prevent the reoccurrence of the subject issue.

7.10 Training

Training of GL environmental, Inc. personnel and supporting documentation facilitates the availability of adequate human resources to support all activities subject to the Quality Policy. Documented training accomplishments are maintained according to control of quality records guidelines (See GL Quality Assurance System Implementation Plan).

GL Environmental, Inc. Quality System Implementation Plan

September 14, 2009
Revision 4

GL Environmental, Inc.
P.O. Box 1746
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Phone: (505) 454-0830
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Subject: Quality Assurance Implementation Plan

Revision by: ____ Date: __________________________
Jerusha Rawlings, QA Manager

Approved by: ____ Date: __________________________
Jerusha Rawlings, QA Manager

Approved by: ____ Date: __________________________
Denise Gallegos, Principal Investigator

1.0 Purpose

This plan defines the everyday practices and policies employed by GL Environmental, Inc to ensure quality performance of the services provided.

2.0 Scope

This plan defines the elements of the GL Environmental, Inc Quality System and operational practices to satisfy company and regulatory requirements.

3.0 Definitions

- **Administrative Standard Operating Procedure –** detailed written instructions to carry out prescriptive administrative tasks
- **Equipment Standard Operating Procedure –** written instruction for the operation of equipment employed by GL Environmental, Inc. personnel during monitoring activities and other services provided. Directions include instrument calibration, instrument checks, and procedures for periodic adjustments
- **Field Standard Operating Procedure –** detailed written instructions for monitoring various aspects of groundwater, surface water, process water, soil, vegetation, sediment, and air. Field standard operating procedures include personal protective equipment associated with any monitoring task
- **Principal Investigators -** Duties include management of the corporation and contracts. The PI is also a Principal Professional, i.e. directly responsible for environmental consulting and/or permitting on some project elements.
- **QA Manager –** Ensures that the QA program is fully implemented, including control of the QA manual and standard operating procedures, identifying and documenting conditions adverse to quality, maintaining personnel training files, and assuring that data validation and reporting are performed in accordance with applicable procedures.
- **Quality Policy –** a statement of the intent and commitment level expected by all GL Environmental, Inc. employees.

- **Regulatory requirement –** any governmental rule or law that has bearing on GL Environmental, Inc. activities associated with this document and the Quality Policy.
- **Vendor –** any entity that provides services or equipment to GL Environmental, Inc

4.0 References

GL Environmental, Inc. Quality Assurance Program Manual, Revision 1

5.0 Quality Policy

5.1 GL Environmental, Inc. is committed to providing services of the highest quality. As a contracted environmental consulting company, it is our policy to meet or exceed all customer and regulatory expectations. Our commitment to excellence is employed throughout our company as well as by our contractors.

5.2 It is the commitment of GL Environmental, Inc to provide written and clear procedures; to motivate and empower all employees to achieve the highest level of quality and to provide comprehensive, technically sound services to all clients; and to conduct business with the highest standards of ethics and integrity.

6.0 Quality System

The GL Environmental Quality System is documented within the Quality Assurance Program Manual. Execution of the system is described in the text of this Quality Assurance Implementation Plan, the associated GL Environmental, Inc. Administrative Standard operating Procedures (SOPs), Equipment SOPs, and Field SOPs. Other GL Environmental, Inc. program specific documents may augment the overall quality system. These documents establish procedures for quality related activities throughout the company and ensure compliance with regulatory requirements and the GL Environmental, Inc. Quality Policy.

7.0 Elements of the Quality System

7.1 Principal Investigators

Principal Investigators are the most senior employees at GL Environmental, Inc. and provide guidance for company operations. The ultimate responsibility for quality rests with the Principal Investigators. The QA manager reports directly to the principal investigators for Quality System-related activities. The Principal Investigators ensure sufficient emphasis and resources are allocated to the Quality System to ensure that all objectives of the system are established and maintained.

7.2 Organization

GL Environmental Inc.'s organizational structure facilitates the establishment of defined authority and responsibility within the management system. This structure encourages a high level of performance for all employees.

7.2.1 Principal Investigator (PI) – Duties include management of the corporation and contracts. The PI is also a Principal Professional, i.e. directly responsible for environmental consulting and/or permitting on some project elements.

7.2.2 Project Manager – Develops sampling strategies and protocols, supervises sampling events (collection and shipment), and generates analysis reports. The project manager provides direction to clients to maintain regulatory compliance.

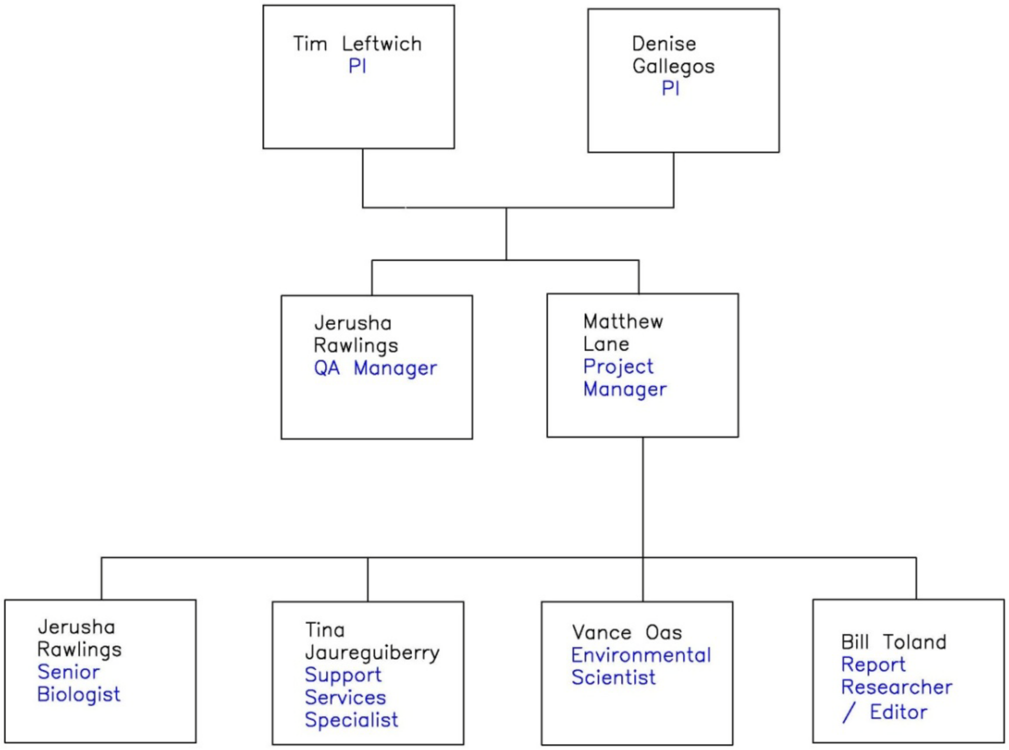
7.2.3 QA manager – Ensures that the QA program is fully implemented, including control of the QA manual, QA implementation Plan, standard operating procedures, identifying and documenting conditions adverse to quality, maintaining personnel training files and assuring that data validation and reporting are performed in accordance with applicable procedures.

7.2.4 Senior Biologist – Provides technical expertise for environmental monitoring activities, including biological survey design, implementation, analysis, and report writing.

7.2.5 Environmental Scientist – Provides sampling support for groundwater, surface water, process water, soil, vegetation, and air. The Environmental Scientist may also provide project coordination, supervisory, planning, researching, and data analysis services.

7.2.6 Support Services Specialist – Provides document control by assembling, binding, shipping (hand delivery, mail, UPS, Fedex), proof reading, copying, and filing. The Support Services Specialist also provides on-demand researching services and may also provide other office and personnel support, including supply procurement, cleaning and decorating, vehicle maintenance, and other errands.

7.2.7 Organizational Chart



7.3 Responsibility and Authority

GL Environmental, Inc. management will provide the resources, tools, equipment, scheduling and training to ensure that all staff and each phase of the company operation conform to the requirements of the quality system. The QA manager has the responsibility to identify and direct activities to achieve systematic compliance with the Quality System throughout the organization. The QA manager has the definitive authority to advance the Quality System objectives for standard company operations and all GL Environmental, Inc. employees have the responsibility to promote the Quality Policy within the scope of their duties.

7.3.1 The QA Manager is responsible for implementing and monitoring the Quality Assurance Program and will have knowledge of all GL Environmental, Inc. standard operating procedures.

7.3.2 The QA Manager reports directly to the principal investigators.

7.3.3 The QA Manager has sufficient authority, access to project areas, and company work force with sufficient independence from cost and schedule considerations.

7.3.4 The QA Manager – without any managerial influence – can identify and record any problems affecting the quality systems; issue corrective action reports; initiate actions, and to to initiate, recommend, or provide solutions to problems; and verify implementation of solutions.

7.4 Documentation / Procedural Structure

Protocols for technical and prescriptive administrative tasks are described in detail in Standard Operating Procedures (SOPs). GL Environmental, Inc. classifies SOPs under three categories: field, equipment, and administrative.

7.4.1 Field SOPs

F001	Personal Protective Equipment
F002	Field Logbook
F003	Chain of Custody
F004	Decontamination of Sampling Equipment
F005	Collection and Preservation of Water and Wastewater Samples
F006	Well Purging and Sampling Procedure
F007	Domestic Wastewater Sampling
F008	Surface Stormwater Sampling
F009	Stormwater Basin Sediment Sampling
F010	Soil Sampling
F011	Plant Tissue Sampling
F012	Vegetation Sampling and Analysis (cover, diversity, shrub density, and production)
F013	TLD
F014	Continuous Air Sampling
F015	Mammal Survey
F016	Reptile and Amphibian Survey
F017	Breeding Bird Survey
F018	Wintering Bird Survey
F019	Lesser Prairie Chicken (*Tympanuchus pallidicinctus*) Sampling
F020	Animal Tissue Sampling
F021	Shipping and Handling of Environmental Samples

7.4.2 Equipment SOPs

E001	Continuous Air Samplers
E002	Water Level Indicator
E003	Multi Probe System (MPS)
E004	Point Source Bailer
E005	Submersible Sampling Pump
E006	Global Positioning System (GPS)
E007	Generator

7.4.3 Administrative SOPs

A001	Corrective Action
A002	Control, Retention, and Disposal of Quality Assurance Records
A003	Vendor Approval and Audits
A004	Employee Safety Training
A005	Employee Field Sampling Training

7.5 Control of Measuring Equipment

7.5.1 To ensure control of service quality, GL Environmental conducts instrument calibration, instrument checks, and periodic adjustments to monitoring equipment. Inspections and calibrations are carried out as outlined in GL's equipment SOPs.

7.5.2 Calibration records are maintained as part of GL Environmental Inc. Document Control and Retention program

7.6 Document Control and Record Retention

GL maintains fastidious documentation of all activities associated with the QA program. Examples are project files, logbooks (field observations, conversations, calls, etc.), corrective action reports, employee proficiency test results, SOPs, manuals, training records, chains of custody, computer records and backups. All records are protected from damage and unauthorized access.

GL incorporates procedures to ensure that documents generated for reference are initiated, changed, and controlled to ensure use of only active and accurate documents. It is the GL Environmental, Inc. policy to control laboratory documents as follows:

7.6.1 Documents are maintained for a period of five (5) years. These records are made available to client's representatives and may be maintained for longer or shorter periods when agreed upon contractually.

7.6.2 Administrative Procedure "A002 – Control, Retention, and Disposal of Quality Assurance Records" is in place to control documents and data.

7.6.3 A document will periodically be submitted for review and revision. Once authorized for use by the Project and QA managers, it is controlled.

7.6.4 For internal use: Documents are placed on the company server for quick access and reference in a format that prevents any unauthorized changes. The original hard copy will always document Identifier and is retained in the company filing system

7.6.5 For external use: Upon request, documents will be distributed to clients, business partners, or representative of regulatory agencies in a format that prevents unauthorized changes. The distribution may be controlled or uncontrolled. Controlled status assures the continuous distribution of the latest revision of a document. Uncontrolled status is the single submittal of the latest revision of the requested document.

7.7 Quality of Purchased Items and Services

7.7.1 Any vendors that provide analytical data are procured through the use of a Quality Assurance Purchase Order (PO). This document requires the vendor to adhere to, at a minimum, GL's quality assurance program as well as any specifications required by the client.

7.7.2 GL requires that any contracted analytical laboratory hold current National Environmental Laboratory Accreditation Program (NELAP) accreditation.

7.7.3 If contractually required or at a client's request, GL will perform audits of selected vendors through the use of a qualified, independent third-party.

7.8 Inspections and Audits

GL performs periodic inspections of all elements of its QA program to verify conformance of each item or activity to specified requirements.

7.8.1 Inspections results are maintained as part of GL Environmental Inc.'s Document Control.

7.8.2 Audits will be performed on selected vendors through the use of a qualified, independent third-party if required or requested to confirm that all components of GL Environmental, Inc.'s services comply with our Quality Policy.

7.9 Corrective and Preventative Action

The systematic and integrated deployment of effective solutions that eliminate the root cause and prevent the production of substandard products is the ultimate outcome of corrective action activities. Documented procedures and records associated with corrective actions are developed and maintained by the Quality System.

7.9.1 All potential or actual non-conformances from all sources (internal and external) are processed through the Corrective Action Report procedure (See Administrative SOP A001). This procedure provides a vehicle to analyze and implement solutions that prevent the reoccurrence of the subject issue.

7.9.2 The project manager is immediately notified if problems are discovered during service activities. The client is then notified of the issue. The incident, actions, and resolution are documented in the "Corrective Action Report Form" (See SOP A001).

7.10 Training

Training of GL environmental, Inc. personnel and support documentation facilitates the availability of adequate human resources to support all activities subject to the Quality Policy. Documented training accomplishments are maintained according to control of quality records guidelines (See SOPs A002, A004, and A005).

7.10.1 At the time of hiring, each GL employee receives a general safety training course that will include instruction on the use of personal protective equipment in the field, such as sunscreen, water, protective clothing, and driver safety. Safety training is repeated on an annual basis.

7.10.2 Those GL employees who conduct field sampling receive training in the use of specialized field procedures and equipment. They also receive safety training specific to the tasks they will be conducting, including preparation for potential exposure to chemical, biological, and other hazardous materials.

7.10.3 All training is in the form of presentations given by a PI, the Project Manager, or the QA Manager. At the conclusion of training, each employee is administered an exam. Appropriate records are kept in a personal folder for each GL employee, including date of training and record of examination.

7.10.4 The proficiency of each employee is routinely evaluated to demonstrate their capability of performing the task to which they are assigned. The minimum acceptable score for general initial and continuing proficiency testing is 80%. When a trainee performance does not meet the acceptance criteria, the course of action is remedial training and subsequent retesting.

7.10.5 Training records are maintained according to quality records control guidelines (See SOP A002).

ORTIZ MINE

QUALITY ASSURANCE PROTOCOLS FOR SURFACE AND GROUNDWATER SAMPLE COLLECTION AND MANAGEMENT

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(June, 2013)

CONTENTS

ORTIZ MINE

QUALITY ASSURANCE PROTOCOLS FOR SURFACE AND GROUNDWATER SAMPLE COLLECTION AND MANAGEMENT

1.0 PROJECT DESCRIPTION

This document establishes the quality standards for products and services that have been established within the industry and through government regulations. Santa Fe Gold and its contractors shall meet or exceed these quality standards throughout the duration of the project.

1.1 Background

The purpose of this document is to help ensure that water quality data collected are reliable and repeatable, and represent as much as possible, given the current methods and state of geochemistry, the actual condition of the water being sampled. Reliable water quality data are essential to the impartiality and credibility of information used for investigations and in decision making.

This document assumes that professionals collecting water samples have an understanding of the physical sciences, and have basic experience in field work (such as an undergraduate level field course), and have experience in the collection of surface and groundwater samples. This document is not all-inclusive and the author(s) cannot predict all circumstances and conditions that the professional may encounter in the field. The field professional is encouraged to make reference to industry accepted guidelines, the laboratory that will be processing the samples, peers, and supervisors as circumstances and conditions warrant.

Much of the information contained in this document was derived from sources such as the United States Geological Survey (USGS) *National Field Manual for the Collection of Water-Quality Data*, industry best management practices (BMP), laboratory guidelines, Environmental Protection Agency (EPA) standard operating procedures (SOP), and field experience.

This document covers the basic procedures for groundwater and surface water sample collection, collection of field water quality data, management of the water samples collected, and documentation. Since not all aspects or conditions of water sampling can be foreseen it is the responsibility of the field professional to make use of his or her education, training, good judgment, consultation with peers or supervisors, manufacturer’s instruction manuals, and other appropriate guidance documents to eliminate uncertainty as much as possible. As such, this document is not all-inclusive and no warranty, expressed or implied, is made.

1.2 Field Preparation

Prior to going in the field the professional shall:

1. Obtain instructions for the sampling to be conducted, including sampling locations, map(s), driving directions, access instructions, analysis to be conducted, depth and construction details of wells (as applicable), depth of samples to be collected (as applicable), methods used for the collection of samples, and any special instructions.

2. Contact the laboratory that will process the samples to inform them of the analysis required and schedule the delivery of coolers, chain of custody forms, chain of custody seals, sample containers, filters (and a few extra sample kits). Obtain information from the laboratory indicating sample management requirements such as sample holding times, sample preservation, filtering, and storage temperature.

3. Ensure adequate field materials and equipment is available for the sampling event. Check the condition, calibration, and operation of water quality instruments, pumps, and other equipment prior to leaving for the field. (Remember, consumables such as bailers cannot be purchased locally and must be obtained prior to the sampling event!)

4. As applicable, several days prior to sampling *and* on the day prior to sampling, contact the landowner(s) and/or land manager(s) to inform of the date and approximate time that the sampling will take place. Discuss access issues. (It is assumed that permission to sample has already been granted.)

5. State requirements may exist requiring a number of days or hours of notice to be given prior to sampling. As appropriate, prior to sampling inform any applicable government agencies and/or state project manager(s) of the date that the sampling will take place. It is advisable to use e-mail for this purpose if appropriate. If using a telephone keep a written phone record.

1.3 Documentation

A field notebook shall contain the following attributes:

1. Be of a type with permanently attached pages.
2. Preferably water-resistant.
3. Pages shall be numbered.
4. Permanent ink shall be used.
5. Inside the front cover and on the first few pages the book shall contain the following:
    a. The project number(s) and/ or project name(s).
    b. The names and initials of each person authorized to make entries.
    c. A table of contents shall be created listing each field visit/project and date(s).
    d. A list of abbreviations.

   e. The date that the field book was initiated, and once the field book becomes full the date that the field book was closed. If a field book becomes full and the project is carried into a new field book, the old book must be annotated, “Book 1 of ___” and the new field book annotated, “Book 2 of ___” and so on.
6. Each page heading shall contain the following:
   a. Date
   b. Project number and/or project name
   c. Initials of person(s) making entries
   d. Page number (may be on the bottom if printed within the book)
7. Each entry shall contain the following attributes:
   a. Local time of entry.
   b. Entries shall be clearly legible and be detailed enough for a person that was not in the field to understand the entry. Avoid slang or excessive use of acronyms or abbreviations. Make entries in plain English that can be easily understood and not misinterpreted. Entries shall be made in permanent ink.
   c. If a mistake is made only one line shall be used to cross out the mistake and initials and date shall be written next to the lined-out mistake. The lined-out entry should still be legible. Mistaken entries shall never be scribbled out or otherwise obscured as to make them illegible. If necessary, enter a statement as to why the mistake was made (usually not required for simple or obvious mistakes).
   d. Empty space not used on pages shall be crossed out, initialed, and dated. No page shall be used for entries made on more than one date. A new starting page shall be initiated each day.

External forms may be used (such as pre-printed tables and other forms), but an entry must be made in the field notebook indicating that a form is being used for the field data in lieu of the field notebook, e.g. “10:15 – See well form for water quality data and volume bailed from MW-1.” External forms must contain a title, project number and/or project name, name of the person making the entries, date, and time(s) of entries.

At the start of each day the field professional shall write a short entry in the field book describing the objectives for the day.

A list of contact information will be placed in the back of the field book containing names and phone numbers of persons related to the project such as project managers, landowners, the laboratory, subcontractors, etc. Field notes need to be of sufficient quality to stand up in a court of law.

1.4 Safety

Common sense and good field judgment are essential to carrying out a safe and productive field project. For example: *As the field day approaches there has been a lot of precipitation and the task is to collect surface water samples.* It might be prudent to check access and make sure storm water runoff does not block road way and prevent safe return. Change plans or find another way to do it safely.

Before going to the field the subject of safety must be addressed. Ideally, the organization has established a safety and/or accident prevention program. Before field operations begin a health and safety document should be generated that addresses safety concerns specific to the project.

Additional training may be necessary depending on the waters to be sampled. For example if working with water contaminated with hydrocarbons or hazardous materials it may be necessary to receive Hazardous Waste Operations and Emergency Response (HAZWOPER) training. If sampling wells near natural gas or petroleum facilities (especially sour gas and oil) the wells may expel hydrogen sulfide (H_2S), an extremely poisonous gas. In this case it would be prudent (and maybe lifesaving) to receive H_2S awareness training and monitor the air using specialized equipment.

If two or more people are involved in the field project a safety briefing should be conducted each day or more often if needed. The briefing should address potential safety concerns specific to the project, conditions, and environment. Annotate the subject(s) of the safety briefing and participant names in the field notebook. If alone, make an entry in the field notebook describing potential safety concerns.

Personnel who collect water and sediment samples will be required to have Occupational Safety and Health Administration (OSHA) training requirements defined in Title 29 of the Code of Federal Regulations (CFR) Part 1910.120€. Equivalent Mine Safety and Health Administration (MSHA) would also be considered acceptable safety training. As needed for the project, personnel will wear the appropriate personal protective equipment (PPE) and adequate First Aid training and kits.

2.0 DATA COLLECTION

There are probably just as many sampling devices and techniques as there are sampling environments and project requirements. For this reason only the most common sampling techniques will be covered. If a technique or piece of equipment is not covered in this document, consult the project manager, knowledgeable peers, project work plan, guidance document, or manufacturer's instructions.

2.1 Sampling Design

Samples or data will be collected as outlined in the Sampling and Analysis Plan (SAP). Planning field activities will require design of methods and procedures, coordinating schedules, and sharing of data with other contractors to minimize duplication of data.

2.2 Groundwater Gauging and Sampling

To prevent cross-contamination of wells it is advisable to use clean, new, disposable equipment as much as possible. Disposable equipment for groundwater sampling is usually the bailers, rope, protective gloves, wipes, pump tubing, and anything else that may come in contact with the well or the water within. Do not remove it from the packaging until ready for use. Do not use this equipment on other wells and remember to change gloves between wells.

Some equipment is not disposable such as depth to water meters, interface probes, and pumps. These must be thoroughly decontaminated between wells with a three-stage decontamination process consisting of a wash in water solution containing a detergent such as Alconox, thoroughly rinsed in clean drinking water, then rinsed in clean de-ionized or distilled water. Submersible pumps can be problematic due to their internal parts being hard to clean. They can be used, but care must be taken when decontaminating them. At a minimum, if it cannot be disassembled, run the pump in the cleaning solution, drinking water rinse, and de-ionized rinse for a few minutes each. If a pump must be used, use a peristaltic pump if possible. Only the disposable tubing comes in contact with water using a peristaltic pump.

Gauging depth to groundwater and depth to bottom:

To determine the saturated volume of a well and elevation of groundwater, depth to water must be measured. If the total depth of the well is unknown the depth to the bottom must also be measured. A depth to water probe can be used for this purpose. If there is light aqueous phase liquid (LNAPL) in the well (such as oil floating on the groundwater), then an interface probe can be used to detect both depth to LNAPL and depth to groundwater. Following area procedures for using a depth to water probes or interface probes.

1. If the wells are in close proximity open all the wells to allow the hydraulic head to equalize with atmospheric pressure.
2. If contamination is suspected or known, work from the least contaminated well to the most contaminated well if possible.
3. Prior to use ensure that the probe and its tape have been decontaminated. Thoroughly decontaminate the probe and its tape between each well, and change gloves between each well.
4. Turn the probe on, press the test button, and listen for a “beep.”
5. Slowly lower the probe into the well.
    a. With most interface probes a solid tone is heard when the probe touches LNAPL and an alternating tone is heard when the probe touches water.
    b. With most depth to water probes only a solid tone is heard.
6. Determine the depth to LNAPL and/or water from the top of well casing to the nearest $1/100^{th}$ of a foot (or millimeter if using a metric probe). Record the measurement(s).
7. Turn the probe off.
8. If the depth to the bottom of the well is unknown, lower the probe to the bottom of the well and record the measurement.
9. When raising the probe, place the tape into a bucket of detergent/water solution. Pile it into the bucket the same way kayakers pile ropes into their rope bags. Decontaminate the tape and probe and dry it with paper towels while cranking it back onto the spool.
10. If the top of the well casing has been surveyed for elevation, nothing more needs to be done. If it has not been surveyed the well stick-up or depth of casing below ground surface should be measured and recorded.

Be careful when lowering the probe into a well equipped with a pump or other equipment. The probe can easily get caught in wire harnesses, hoses, or pipes. Wells in active use such as domestic or industrial supply wells, if recently pumped, may not reflect an accurate potentiometric surface due to a cone of depression. It may not be worth the risk of losing a depth probe in such a well.

Water condenses inside the casings of wells made from steel. As the probe is lowered into a metal casing water can collect around the probe end and can give a false depth to water signal. Turning the sensitivity down or listening for a stronger tone may be required to accurately determine depth to water. It is helpful to know what the approximate depth to water is in a steel well prior to gauging it.

2.3 Well Purging and Sampling

In most instances purging a volume of water from a well is required before sampling to ensure that water from the geologic formation or native soil is being sampled, not water that has been sitting in the bottom of the well.

Basic purging and sampling with a bailer or pump (read these instructions, as the other sampling methods use some of the same techniques):

1. Use a new, unopened, unused disposable bailer if possible. If using a re-useable bailer it must be thoroughly decontaminated before use.
2. The string or rope used should be new. It is difficult if not impossible to effectively decontaminate string or rope.
3. Open the bailer wrapping at the top and attach the rope with a secure knot.
4. Remove the bailer the rest of the way from its wrapping and slowly lower it into the well. Once it comes into contact with water, let it sink 1-1/2 to 2 bailer lengths below the water surface. Roll out some extra rope, cut it from the spool and tie it to something secure.
5. With a very slight tug to seat the ball valve in the bottom of the bailer, raise it to the surface. While raising the bailer the rope should not be allowed to touch the ground. Either spool the rope with the hands held about three or four feet apart or use a spooling device such as an extension cord spool. Keep in mind that spools must be thoroughly decontaminated between wells.
6. Keep bailing until at least three well volumes of water have been removed or an adequate volume of water has been removed as determined by work plans or instructions. Although not always the case, when temperature, pH, and conductivity have stabilized, formation water has likely entered the well and it may be ready to sample. Consult project plans to be sure.
7. To sample:
    a. With small bottles such as the glass VOAs used for volatile organic compounds attach an accessory tip (a straw-like device) to the bottom of the bailer and fill the VOA forming a meniscus at the top of the bottle. Pour slowly to minimize aeration of the sample, and to avoid losing the preservative be careful not to overflow the bottle. Screw the cap on and confirm that there are no air bubbles in the bottle.
    b. With larger bottles such as the amber bottles used for semi-volatile organic compounds it may be easier to simply pour it in from the top of the bailer. Pour slowly to minimize aeration of the sample.
    c. If filtering is needed such as for dissolved metals (and other ions), a large syringe can be used to extract the water from the bailer then press it through the filter and into the sample bottle. Another way is to use a peristaltic pump to push water through the filters. Do not re-use filters. With either of these methods it is important to use a new syringe or new length of tubing for each sample.
8. Label and wrap all the bottles and place them into a cooler with ice as soon as possible. Do not let sample bottles sit out in the sun. Enter the samples onto the chain of custody form.

Sampling with a pump is similar. Use new, never used tubing for each well and ensure that the pump has been thoroughly decontaminated. The advantage of a pump is that a flow through cell can be used to accurately record dissolved oxygen and oxidation-reduction potential (with bailers these parameters are not as accurate), and it is easier to sample from the hose connected to the pump. If a large volume must be purged pumping may be the only way to purge an adequate volume. Some projects may require pumps to be used for “low flow” sampling.

If the well bails dry before an adequate volume of water is purged, contact the project manager or work plan for instructions. Depending on project objectives, sampling this well may lead to questionable results that are not worth the cost of laboratory analysis.

When the sampling day is over it is a good idea to replace the ice in the coolers. Ice that has been in a cooler all day is at about 32°F. It can do nothing but melt, and may be completely melted by morning or by the time the cooler reaches the lab. Most freezers are maintained at 0°F, so ice that is fresh from a freezer has to warm 32 degrees before it starts to melt. This extends the time that a cooler will stay cold enough to meet laboratory requirements.

Domestic or industrial water supply well purging and sampling:

It might not be possible to gauge depth to water in a domestic or industrial well. Determine purge volume if possible by other means. Consult with the project manager or work plan to determine a course of action. If it is not possible to determine purge volume the most common procedure is to purge the well until field water quality parameters such as temperature, pH, and conductivity have completely stabilized then take the samples. Use the water spigot closest to the well and outdoors if possible. A hose can be used while purging, but it should be removed for sampling.

2.4 Surface Water Sampling

Surface water samples are typically grab type samples collection in laboratory supplied containers with preservatives.

2.5 Sample Handling and Custody

Standard practices followed by the United States Geological Survey (USGS), New Mexico Environment Department (NMED), and New Mexico Office of the State Engineer (NMOSE) will be employed for sampling collection, handling, and chain of custody documentation. Samples will be give an identification number or name with associated collection date, location, time, collector’s initials, and requested laboratory analysis. Accredited laboratory issued labels and chain of custody documents will implemented for laboratory analyses.

2.6 Laboratory QA/QC

The accredited laboratory will provide a standard QA/QC report with all reports. The JSAI project Management will review all QA/QC documentation to make sure project needs have been met.

2.7 Equipment Testing, Inspection, Maintenance, and Calibration

All equipment and meters used for collection of field data will be calibrated to the manufacturers specifications prior to performing the data collection.

2.0 DATA EVALUATION

Collected data will be evaluated for by the JSAI project manager to make sure the information and data are sufficient for the project and reporting. All databases developed for the project will contain notes on the data verification, and justification for corrections.

Appendix D – Hydrogeology of the Ortiz Mountains and Vicinity

HYDROGEOLOGY OF THE ORTIZ MOUNTAINS AND VICINITY

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Abstract--Runoff from the Ortiz Mountains recharges sedimentary rocks peripheral to the range at about 1480 acre-feet per year, and moves radially away, draining to Arroyo Tuerto, Arroyo la Joya, Galisteo Creek and the Rio Grande. A small proportion emerges as springs. Transmissivity of the sedimentary beds is markedly enhanced in and near the Golden fault zone. Within the Ortiz range, the small recharge moves vertically, mostly in fractures, under unsaturated conditions; except for the Golden fault zone, which receives large recharge and is saturated to an elevation of about 7200 ft at Carache Canyon, the top of the saturated zone within the mountains may be below 6800 ft. Transmissivity of the fault zone is 400-440 ft^2/day.

INTRODUCTION

This paper summarizes and makes available the results of extensive hydrogeologic studies, including preparation of a single-layer regional ground-water flow model, in and around the Ortiz Mountains. Although little has been published, most of the basic information is available in the files of the State Engineer Office (SEO) in Santa Fe.

The first detailed studies of the hydrogeology of the Ortiz Mountains were by W. K. Summers, for Azcon Corporation and Gold Fields Corporation, beginning in 1976. Gold Fields operated the Ortiz open-pit gold mine from 1980 to 1987; pumping for water supply and dewatering of the mine has been the only significant withdrawal of water in the vicinity. Summers' reports are in SEO files under File No. RG-32970 et al.

The writer's studies, in 1988 through 1993 for Pegasus Gold Corp. and Lac Minerals (USA), Inc., have been related to water supply and dewatering of workings for proposed mining and beneficiation projects in the Carache Canyon area, and farther to the southwest (Fig. 1). These studies, partly in collaboration with James W. Mahar, are in SEO files under File Nos. RG-51887 and RG-50321.

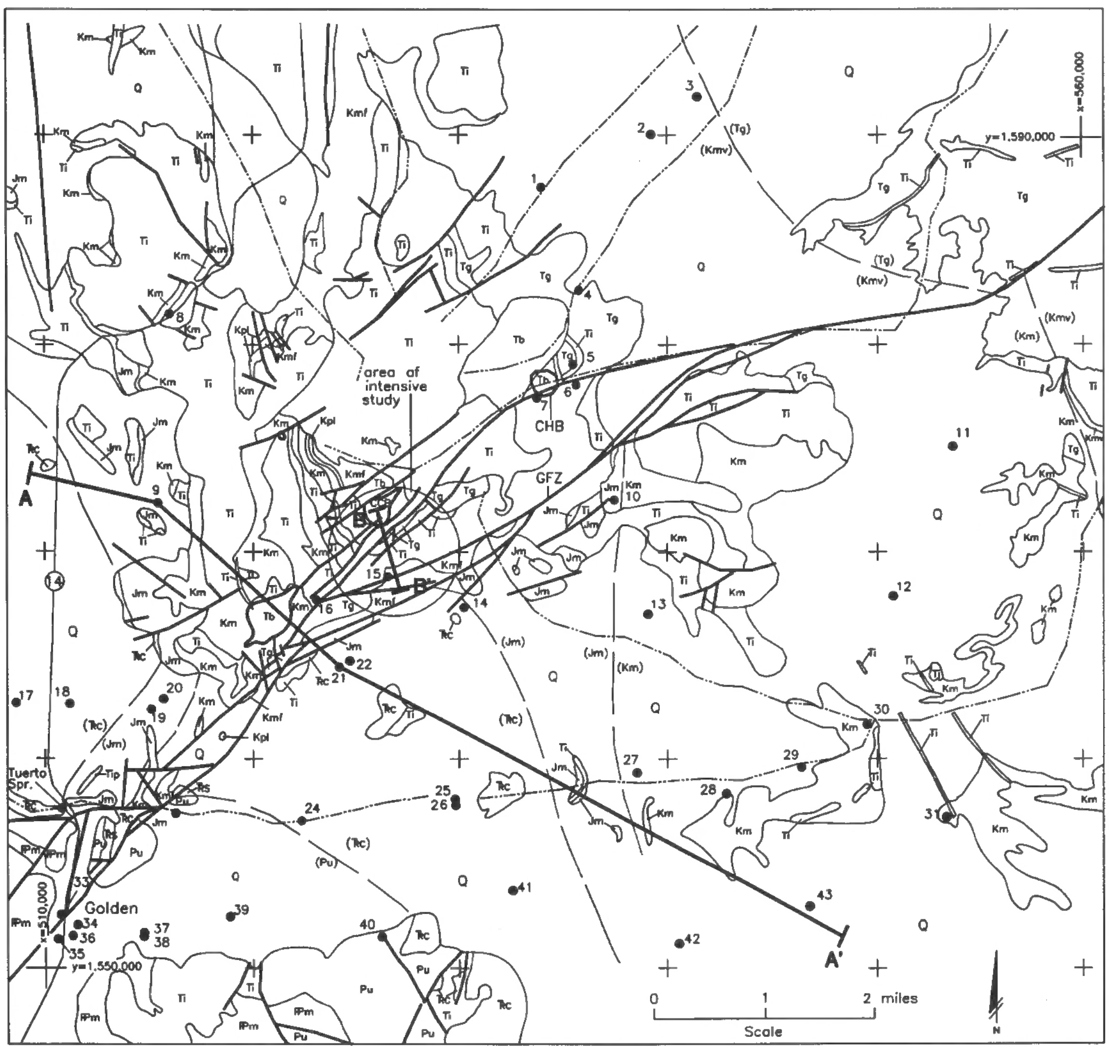

FIGURE 1. Geologic map of Ortiz Mountains and surrounding area, after Bachman (1975) and unpublished mapping by Pegasus Gold Corp. geologists. Heavy lines are faults: GFZ, Golden fault zone. Long-dashed lines are inferred subcrops beneath alluvium. Stratigraphic units: Q, Quaternary-age alluvium, colluvium, and fluvial sediments; Tb, Tertiary breccia (CHB, ore body in Cunningham Hill breccia pipe; CCB, Carache Canyon breccia pipe); Ti, Tertiary intrusive rocks; Tg, Galisteo Formation; Kmv, Mesaverde Group (including Kmf, Menefee Formation; and Kpl, Point Lookout Sandstone); Km, Mancos Shale; Kd, Dakota Sandstone; Jm, Morrison Formation; Je, Entrada Sandstone; Trc, Chinle Formation; Trs, Santa Rosa Sandstone; Pu, Permian rocks, undivided; Psag, San Andres Limestone and Glorieta Sandstone; Py, Yeso Formation; Pa, Abo Formation; Pm, Madera Formation.

HYDROGEOLOGIC PROPERTIES OF ROCK UNITS

The geologic units that constitute the system of aquifers and confining beds are shown on the geologic map and cross-section, Figures 1 and 2. Descriptions of these units may be found in many papers, particularly the studies by Stearns (1953), Disbrow and Stoll (1957), Kelley and Northrop (1975), Bachman (1975) and Maynard et al. (1990); the reports by Summers include a comprehensive summary of the stratigraphy. In this paper, emphasis will be on hydrogeologic properties of the units.

Small supplies for domestic and stock-watering use are obtained from wells in all stratigraphic units shown. Large-capacity wells have been completed in the Madera, San Andres, Glorieta, Morrison, and Mesaverde formations (Table 1). Table 1 includes only those wells (and one spring) for which data as to aquifer or water-quality properties are available; there are many other wells, hundreds of mineral-exploration holes, and many small springs within the area of Figure 1.

Most aquifer tests are summarized in Table 1. Transmissivity values given are for the partial thicknesses of the aquifer open to wells, and where a range is shown, transmissivity was calculated by more than one method, or the analysis was complicated by boundary effects. In some tests, the specific capacity of the well was greater than would be consistent with a storage coefficient in the confined-aquifer range, even though the aquifer is fully saturated and lies beneath lower-conductivity beds. This phenomenon may be attributable to leakage through vertical fractures. In addition to conventional pumping tests of wells in the area surrounding the range, there have been extensive studies (described below) of hydrologic properties and ground-water flow in two areas within the mountain itself.

Madera Formation

The Kelly Replacement well (no. 37, Fig. 1, Table 1) is completed in the Madera. Results of the aquifer test showed the influence of fracture-flow. A 68-hour constant-rate test at 450 gallons per minute (gpm) gave a specific capacity of about 8.4 gallons per minute per foot of drawdown (gpm/ft), and a transmissivity of about 2390 feet squared per day (ft^2/day) based on drawdown measurements after 300 minutes (Table 1). Analysis of recovery data gave a much higher apparent transmissivity, probably influenced by delayed recovery due to refilling of fractures near the water table. The hydraulic conductivity of the Madera is probably much less where the unit is at greater depth and unfractured.

San Andres Limestone, Glorieta Sandstone and Santa Rosa (?) Sandstone

The Iron Vein test well (no. 21, Fig. 1, Table 1) is completed open-hole in the Glorieta Sandstone (1425-1495 ft; depths are below ground level), the San Andres Limestone (1290-1425 ft), the Santa Rosa Sandstone (1070-1180 ft), mudstone beds of the lower part of the Triassic section, and thick andesite porphyry sills. The well is close to the Golden fault zone, and it was hoped that deep ground-water circulation associated with the fault zone had led to enhancement of permeability by solution in the San Andres, but this seems not to be the case. The well was tested for 8 hours at about 50 gpm, with a specific capacity of only about 0.3 gpm/ft. Transmissivity of the entire open interval was estimated at about 75 ft^2/day.

Well TB-14 (no. 18, Fig. 1, Table 1) was tested by W. K. Summers, who estimated transmissivity at 3460 to 5010 ft^2/day. Here the San Andres is beneath the basal Chinle Formation and perhaps beds of the Bernal Formation, but at shallow depth (the well is 275 ft deep), and it is clear that hydraulic conductivity has been enhanced by solution.

Chinle Formation

A test of well TB-11 (no. 24, Fig. 1, Table 1), by Summers, was interpreted to give a horizontal hydraulic conductivity for the 68-ft open interval of about 0.05 ft/day. Summers concluded that "as much as 90 percent of the water was derived from beds overlying or underlying the interval," and that vertical hydraulic conductivity is much larger than the horizontal component, owing to fracturing. Transmissivity of the lower part of the Chinle and Santa Rosa Sandstone, derived from ground-water flow model calibration as described below, is approximately 14 ft^2/day.

Morrison Formation

There have been two tests of wells in the Morrison Formation, one, an injection test by Summers of well LM-1, and the other of well LC-GM-1 (nos. 28 and 20, Fig. 1). LM-1 is far from the Golden fault zone, and probably intersected no fractures; hydraulic conductivity for the 100-ft open interval was estimated at 0.001 ft/day.

Well LC-GM-1 is close to the Golden fault zone, completed in 260 ft (370-630 ft) of yellow, fine-grained sandstone cut by two fracture zones recognized in drilling. The well was tested at 300 gpm, with a one-day specific capacity of 28 gpm/ft and a transmissivity estimated at 16,000 ft^2/day. The apparent transmissivity is doubtless a reflection of fracture flow.

Mancos Shale

The Mancos is not commonly considered an aquifer, but sandstone beds within it may yield water to wells, and igneous intrusions may create local fracture networks which enhance permeability; six wells listed in Table 1 tap the Mancos. Well TB-8 (no. 12, Fig. 1, Table 1) was tested by Summers. The pumping rate was 1.5 to 3.6 gpm, over a total of 6.4 hours, and the specific capacity of the well ranged from 0.11 down to 0.03 gpm/ft of drawdown. Transmissivity was estimated at 2.0 to 5.6 ft^2/day. Transmissivity of the Mancos Shale and Morrison Formation, away from the Golden fault zone, was estimated by model calibration at about 6 ft^2/day.

Mesaverde Group

Seven wells shown on Figure 1 tap the Mesaverde Group, which includes the Point Lookout Sandstone, Menefee Formation and Harmon Sandstone (Table 1). Well OR-3 (no. 5, Fig. 1, Table 1) and the New Las Norias well (no. 4) were tested by Summers. Transmissivity was 60 to 441 ft^2/day for the former and 58 to 75 ft^2/day for the latter, but both wells are in an area of complex structure and much fracturing, close to the Cunningham Hill breccia pipe, and hydraulic conductivity is probably greater than would be found in unfractured Mesaverde rocks.

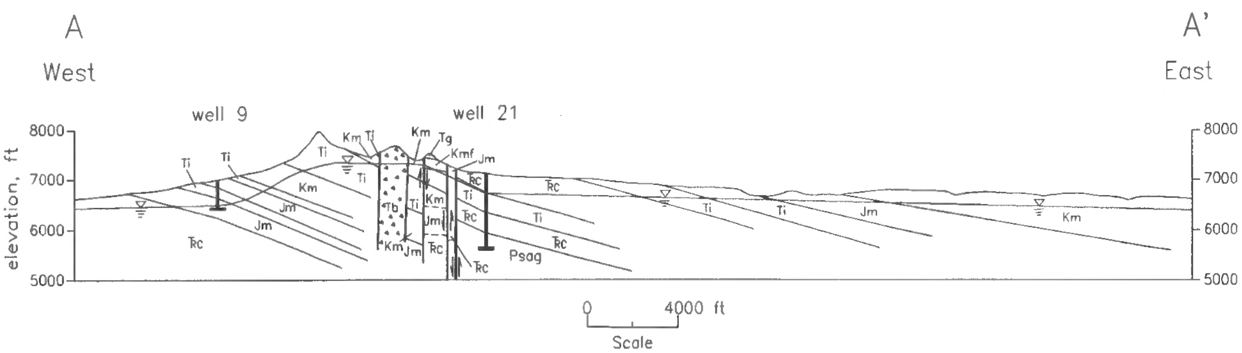

FIGURE 2. Cross-section A-A'. See Figure 1 for line of section and explanation of symbols.

TABLE 1. Summary of records of wells, aquifer tests, and chemical quality of water in Ortiz Mountains and vicinity.

Map index number	Name	Total depth, ft	Aquifer (symbols as Fig. 1)	Elevation, ft.	Depth to water, ft	Date of Measurement	Pumping rate during test, gpm	Transmissivity, ft²/day	Total dissolved solids, mg/l	Reference to SEO File No. for data
1	OBW-2	242	Kmv	6658	51	8-88	--	--	356	RG-32970
2	OBW-4	333	Kmv	6354	73	5-84	--	--	710	RG-32970
3	Pinon 2	700	Kmv	6316	102	8-88	--	--	--	RG-32970
4	New Las Norias	375	Kmv, Ti	6780	41	6-84	14.2	58-75	1091	RG-32970
5	OR-3	566	Kmv	7066	329	6-84	47-150	60-441	685	RG-32970
6	OR-2	535	Ti	7035	261	2-91	--	--	900	RG-32970
7	OBS-64	768	breccia	7180	380	6-84	103	4000	781	RG-32970
8	New Stagecoach	104	Km	6850	32	1-91	--	--	2882	RG-51887
9	Ball 24, Gypsy Q.	575	Jm	6999	512	1-91	--	--	--	RG-51887
10	TB-10	193	Ti	6871	158	12-91	--	--	1100	RG-51887
11	TB-9	80	Tg or Km	6281	23	10-79	--	--	--	RG-51887
12	TB-8	255	Km	6432	27	10-79	1.5-3.6	2-5.6	412	RG-32970
13	Gage	155	Jm	6753	116	11-84	--	--	650	RG-51887
14	TB-4	410	Trc	7088	315	12-91	--	--	658	RG-51887
15	CC-GM-2	500	Kmv	7340	320	10-92	--	--	988	RG-51887
16	Ball 25	235	Kmv, Ti	7380	dry	before 1979	--	--	--	RG-32970
17	TB-19	260	Trc	6577	195	1-91	--	--	--	RG-51887
18	TB-14	275	Psag	6682	206	1-91	2.4-16.7	3460-5010	>650	RG-51887
19	TB-13	310	Jm	6772	298	3-90	--	--	--	RG-51887
20	LC-GM-1	645	Jm	6840	355	3-90	100-300	16,000?	1780	RG-51887
21	IV-TW-1	1500	Psag	7080	378	3-90	50	75?	526?	RG-51887
22	TB-16	?	Trc	7100	393	2-90	--	--	--	RG-51887
23	TB-12	140	Trc	6592	31	1-91	--	--	--	RG-51887
24	TB-11	235	Trc	6730	157	1-91	2.5-8.6	22-610	343	RG-51887
25	TB-18	350	Trc	6815	248	10-79	--	--	--	RG-32970
26	TB-18A	?	Trc	6815	255	10-79	--	--	--	RG-32970
27	TB-1	465	Jm	6617	394	10-79	--	--	--	RG-32970
28	LM-1	690	Jm	6565	280	1-91	0.04	K=0.001 ft/day	2041	RG-32970
29	TB-5	300	Km	6520	117	3-79	--	--	--	RG-32970
30	TB-6	?	Km	6417	29	10-79	--	--	--	RG-32970
31	Bullmill Camp	104	Km	6408	8	1-91	--	--	--	RG-51887
32	Tuerto (Spring)	--	Trc	6480	--	--	5	--	1200±	RG-51887
33	Gilavez	14	Qal	6620	9	10-90	--	--	--	RG-51887
34	Henderson East	--	Pm	6670	33	8-91	--	--	--	RG-50321
35	Henderson West	--	Pm	6645	32	8-91	--	--	--	RG-50321
36	Henderson House	100	Pm	6660	49	8-91	--	--	--	RG-50321
37	Kelly	600	Pm	6819	--	8-91	--	--	--	RG-50321
38	Kelly Replacement	635	Pm	6819	104	8-91	450	2390	400±	RG-50321
39	TB-15	250	Pu, Pm	6846	154	11-79	--	--	--	RG-50321
40	TB-17	450	Pu?	7080	324	11-79	--	--	--	RG-32970
41	TB-3	442	Trc	6887	307	1-91	--	--	--	RG-51887
42	TB-2	595	Trc	6700	454	1-91	--	--	--	RG-51887
43	TB-7	528	Km?	6690	450	3-79	--	--	--	RG-32970

Galisteo Formation

The Galisteo was not tested. Transmissivity derived from model calibration, for the area north and east of the Ortiz Mountains in which the Galisteo is likely to furnish water to wells, is 6 to 31 ft²/day.

Dikes and sills

Several pressure-injection tests of Tertiary intrusive rocks are summarized in a following section and in Table 2.

Cunningham Hill breccia

The breccia pipe includes tuffs and volcanic breccia, fringed by felsitic porphyry and quartzite breccias; the stock intrudes Mesaverde Group beds. The Cunningham Hill (Ortiz Mine) ore body is in one of the quartzite breccias (Nicholson, 1979, p. 27).

A well completed in the Cunningham Hill breccia ore body before mining began (OBS-63; Summers report, SEO File No. RG-32970) produced 39.5 gpm during a 7-day test; hydraulic conductivity was estimated at 5.3 ft²/day. This well is not included in Table 1 because the well and surrounding rock have been removed by mining.

Well OBS-64 (no. 7, Fig. 1, Table 1) was completed in the breccia pipe, but outside the limit of mining, and became a supply well for the operation. It is located in the fracture zone associated with the Golden fault zone. Summers tested the well. A step-drawdown test gave inconclusive results, in that the well continued to develop during pumping,

TABLE 2. Summary of pressure-injection and slug-test results, Carache Canyon area of Ortiz Mountains. Depth is vertical depth to midpoint of 40-ft test interval in angle hole, unless otherwise noted.

Geologic unit or structure	Depth, ft	Flow rate, gpm	Hydraulic conductivity, ft²/day
	pressure-injection tests		
Golden fault zone	185	1.3 - 54.2	0.02 - 0.39
North Golden fault	445	5.0 - 91.0	0.44 - 0.57
trachytic latite dike	470	0.5 - 4.5	0.004 - 0.02
breccia pipe	550	43.2 - 58.0	0.26 - 0.29
	630	0.0 - 0.09	0.0 - 0.0004
	420 - 660	50.6 - 75.8	0.053 - 0.056
breccia/Menefee contact	480	1.8 - 4.2	0.01 - 0.02
minor fault in latite-andesite sill	393	2.9 - 10.6	0.023 - 0.052
	524	3.8 - 33.5	0.023 - 0.14
Menefee Formation	246	5.9 - 17.9	0.07 - 0.11
	297	0.0 - 0.18	0.0 - 0.001
Point Lookout Sandstone	328	0.5 - 6.8	0.005 - 0.037
Mancos Shale/sill contact	459	1.4 - 3.7	0.01 - 0.02
	slug tests (Bouwer-Rice)		
Galisteo Formation	417-503		1.73
Mancos Shale	532-586		0.072
	553-558		0.009
Mancos Sh. (siltstone)	705-711		0.004
Mancos Sh./Point Lookout contact	365-405		0.014

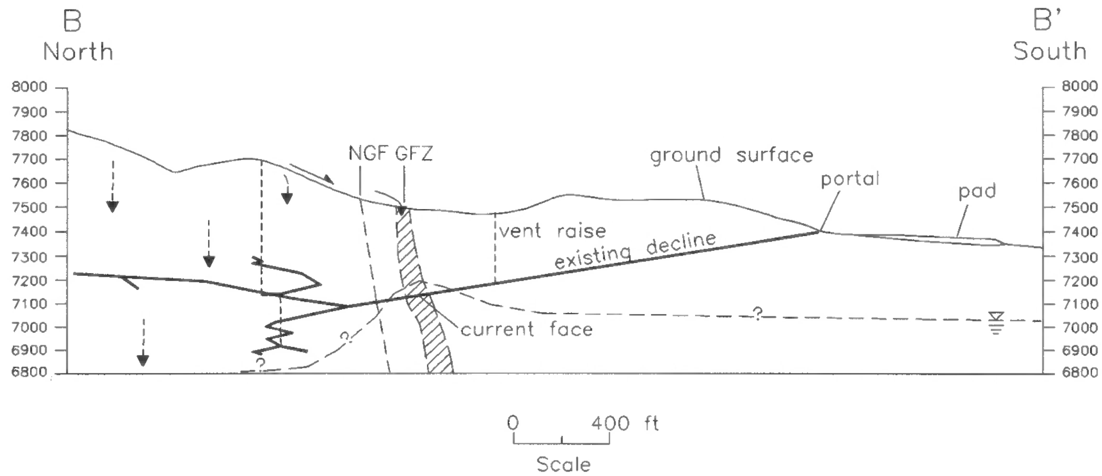

FIGURE 3. Cross-section B-B' along line of Carache Decline; workings shown to north of Golden fault zone (GFZ) are planned. Solid-line arrows represent flow on surface and recharge to Golden fault zone; dashed-line arrows represent vertical flow under unsaturated conditions. Dashed line indicates water table. NGF, North Golden fault. See Figure 1 for line of section.

but a test at a slowly declining rate (from 110 to about 95 gpm), with two observation wells, was interpreted to show a transmissivity of about 4000 ft^2/day (Table 1). Hydraulic conductivity of the breccia was estimated at 5 to 10 ft/day, depending on the estimate of saturated thickness contributing to the well.

Carache Canyon breccia

The Carache Canyon breccia, unlike the Cunningham Hill breccia, consists of angular fragments and blocks of shale and sandstone of the Mesaverde Group and Mancos Shale, and latite-andesite porphyry sills, in a matrix of black, clayey rock flour. The hydraulic conductivity of the breccia as a whole is low, about 0.05 ft/day in one pressure-injection test of a 240-ft-long interval of open hole (Table 2), although individual blocks of sandstone may have much higher conductivity.

GEOLOGIC STRUCTURE

The Ortiz Mountains are the expression of a series of thick Tertiary (30-34 Ma) latite-andesite porphyry sills, intruded into the sequence of Mesozoic sedimentary rocks, and penetrated by several late breccia pipes (Figs. 2 and 3). Sedimentary beds surrounding the mountains dip to the northeast at 5 to 10°. A prominent fault zone, locally called the Golden fault zone but actually an extension of the regional Tijeras fault (e.g., Kelley and Northrop, 1975), lies along the southeast margin of the range. The Golden fault zone, the complex network of other faults associated with it, and the fracturing that accompanies the faults, are important controls on ground-water flow. The role of the Golden fault zone is discussed below.

GROUND-WATER FLOW

Ground-water in sedimentary rocks surrounding the Ortiz Mountains

Potentiometric contours for the area surrounding the Ortiz Mountains are shown on Figure 4. The water-level information from which the contours were derived comes primarily from measurements in wells within the Ortiz Mine Grant, and USGS and SEO records; a summary of the data, which includes records of about 500 wells and springs, may be found under SEO File No. RG-51887. Recharge to the ground-water system occurs principally in the mountain-front of the Ortiz range, and in and bordering San Pedro Mountain and South Mountain. The work of Anderholm (1994, p. 21) near Santa Fe indicates little or no direct recharge at lower elevations in the area of Figure 4.

Flow is, in general, radially away from the mountains, and toward the principal drainages and the Estancia Valley. Arroyo La Joya and Arroyo Tonque are ground-water drains.

Rates of recharge at the periphery of the Ortiz range have been estimated through ground-water flow modeling. A single-layer model was prepared and adjusted to reproduce the steady-state distribution of ground-water head, and then to reproduce the response of water levels to pumping at the Ortiz Mine during 1980 through 1986. The variables in the calibration process were transmissivity and recharge rate, with values for storage coefficient assumed.

The recharge rates were compared with estimates from an analysis (by Summers), based on stream-gaging records, of the ground-water discharge to Galisteo Creek, allocating the origin of all of the inflow to the south side of the creek to recharge bordering the part of the Ortiz range where ground-water flow is tributary to the creek. The results were approximately the same as those derived from the flow model, but each method has serious weaknesses. In the model-based estimate, the assumption of storage coefficient introduces a large potential error that influences the drawdowns in wells. In the other estimate, the proportion of inflow from the each side of Galisteo Creek must be assumed, and this may also lead to error.

Recharge was estimated at an average of 176,000 ft^3/day (1480 acre-ft/yr) for the entire periphery of the mountain range, or roughly 12,000 ft^3/day per mile of mountain-front.

Ground-water within the Ortiz Mountains

Ground water conditions have been examined in two areas within the range: the Cunningham Hill breccia pipe and vicinity at the eastern end

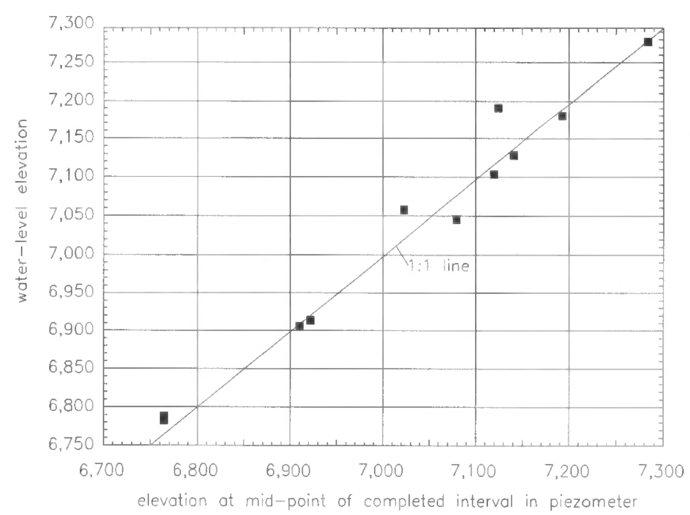

FIGURE 4. Plot of water-level elevation versus elevation of mid-point of screened interval for piezometers in the vicinity of Carache Decline.

of the range, site of the Ortiz Mine, and the area of the Carache Canyon Decline and the Carache breccia pipe (Fig. 1).

Cunningham Hill area

Reports by W. K. Summers describe the Cunningham Hill area. Summers found that,

> Ground water in the Ortiz Mountains occurs in and is transmitted through fractures. Two fracture domains are evident: One occurs within the Tijeras Structural Zone; the other lies on either side. Within the structural zone, hydraulic conductivities of the rocks range from 1 to more than 100 gpd/ft^2 and the specific yield is about 0.005; outside the structural zone, the hydraulic conductivity of the rocks ranges downward from 1. to 0.001 gpd/ft^2 and the specific yield is 0.001 [from Abstract, 1977 report].

Carache Decline area

The Carache Decline (Figs. 1, 3) is an exploratory tunnel about 1720 ft long; proposed extensions of the workings would add about 4661 ft. The present (February 1995) face is within the Golden fault zone. As the decline was originally proposed, all of the workings would have been northwest of the Golden fault zone, and the drilling information available at the time indicated that they would have been entirely in unsaturated rocks. It was recognized that water would be found in fractures and permeable beds, but in general the workings were expected to be self-draining.

The course of the Carache Decline as it was actually driven in 1990 was somewhat different from that of the original proposal, however, and the tunnel intersected the Golden fault zone; a water flow of about 43 gpm was encountered. The operator applied for a permit, under the New Mexico Mine Dewatering Act, to pump a total of up to 122 acre-ft from the workings during a one-year period of underground exploration. Estimation of the inflow to the workings became an issue.

A concentrated study of the hydrogeology of an area of about 90 acres in the vicinity of the Carache Decline was undertaken (Fig. 1). The work included: (1) evaluation of the records of 146 air-reverse-circulation (RVC) mineral-exploration holes (a total of 87,530 ft of vertical and angle drilling) drilled since mid-1989; (2) geologic information from 161 vertical and angle core-holes (162,253 ft in total); (3) five slug tests in piezometers, and 13 pressure-injection tests; (4) evaluation of the inflows to the decline during driving to the present face; (5) a "pumping test" conducted by draining the decline and maintaining a constant water-level for about 9.1 days; and (6) interpretation of the records, which included the period of the pumping test, of 12 piezometers. Records of these studies may be found in State Engineer Office files (File No. RG-50321).

Logs of the air-reverse-rotary holes showed, for each one-foot interval, whether the hole was "dry," "damp," or producing water, and gave estimates of the rates of water production where it existed. Many of the RVC holes were logged as "dry" at bottom-hole elevations well below 6800 ft.

The five slug tests gave hydraulic conductivity values for the Galisteo Formation and the Mancos Shale. The Bouwer-Rice (1976) method, for unconfined conditions, was selected because the test intervals are in the unsaturated zone. The conductivity values are those that would apply under saturated conditions. In the Galisteo Formation at least, these values are probably much greater than the conductivities that actually govern flow in the unsaturated zone.

Pressure-injection tests gave values for saturated hydraulic conductivity for typical rock types, and for several fault zones (Table 2). The tests followed standard methods (e.g., Hunt, 1984), and were at the relatively high pressures required to give conductivity values at the standard 10 bars. The results undoubtedly lead to overestimates of hydraulic conductivity because of opening of fractures by the injection of fluid itself.

Hydraulic conductivity of the Golden fault zone itself was estimated, by the Dupuit relation, from the water-level response in a piezometer in the fault zone during the pumping from the Carache Decline. The pumping rate was a nearly constant 41.1 gpm, once the tunnel had been drained; the piezometer was about 150 ft from the tunnel. The pre-pumping head above the tunnel was assumed equivalent to the water-level elevation in the tunnel before pumping began. The hydraulic conductivity of the fracture zone associated with the almost-vertical Golden fault, estimated at approximately 100 ft wide, was calculated at 0.8 to 2.2 ft/day, depending on the assumption as to saturated thickness. Transmissivity calculated for the fracture zone, however, is in the narrower range 400 to 440 ft^2/day.

The pattern that emerges from the work is that except for the Golden fault zone, flow is vertical, under unsaturated conditions, to great depth within the mountain range (Fig. 3). Flow on the surface recharges the Golden fault zone, and the recharge supports a ground-water ridge along the fault zone. The hydraulic gradient is very steep along its sides. Flow within the fault zone is toward discharge at Tuerto Spring, which rises where the fault zone crosses Arroyo Tuerto (Fig. 1), and into the sedimentary rocks adjacent to the Ortiz range to the northeast.

Drilling may not have reached the water table near the core of the mountains. Information from the piezometers in the Carache area, including a vertical hole to 920 ft (water-level about 892 ft, elevation 6783), shows that ground-water head is approximately the same as well-screen elevation in all cases (Fig. 4); it follows that the vertical-direction hydraulic gradient is about unity, and that flow is downward and under unsaturated conditions except for isolated accumulations in fractures. The top of continuous saturation within the mountains is likely to lie below 6800 ft elevation, even though the water table is several hundred feet higher in the Golden fault zone on the southeast border of the range (Fig. 5).

The relatively low gradients that would be inferred if the top of the saturated zone is near 6800 ft over a large area within the mountain range do not imply that hydraulic conductivity is high, but rather that very little water is flowing. Fracture apertures close with depth, and hydraulic conductivity at 1000 ft or more is likely to be several orders of magnitude less than it is near the surface.

GROUND-WATER QUALITY

A very general indication of chemical quality is given, in terms of total dissolved solids concentration (TDS), in Table 1. Full chemical analyses are available for most of the wells for which TDS is given, and many analyses are available for some wells, in State Engineer Office records under the file numbers indicated.

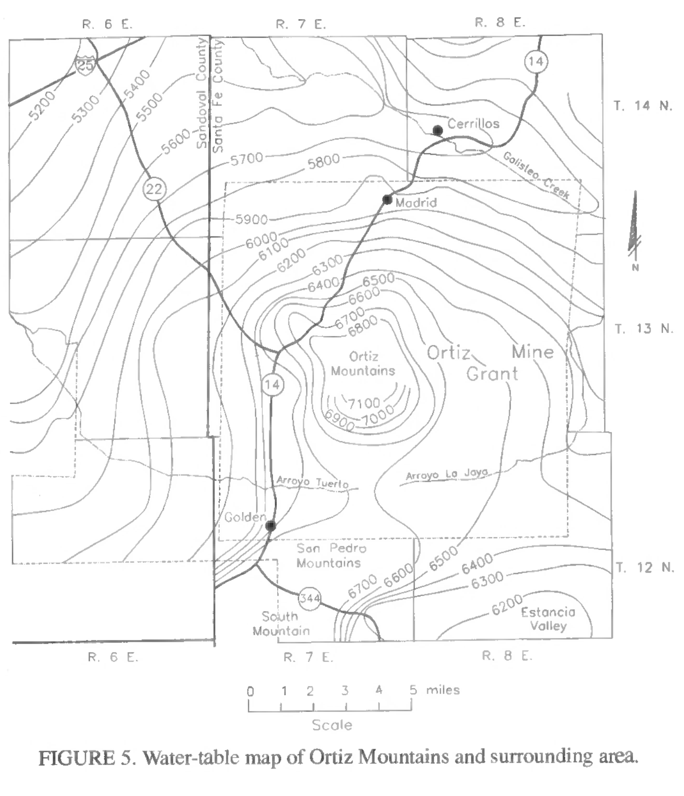

FIGURE 5. Water-table map of Ortiz Mountains and surrounding area.

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