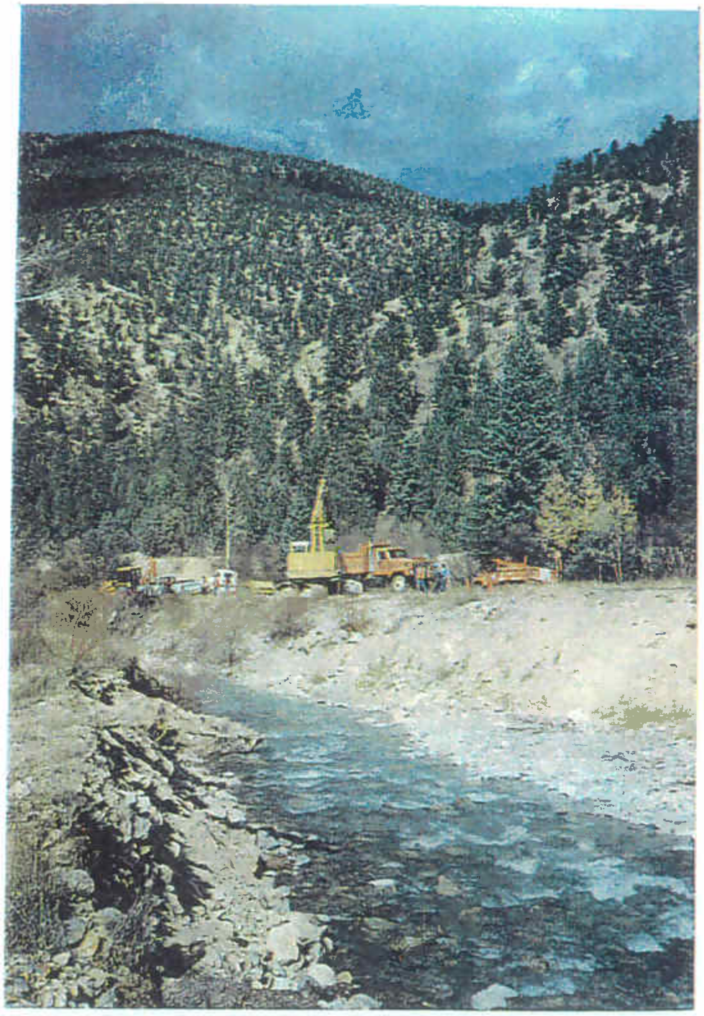

RED RIVER GROUNDWATER INVESTIGATION

Final Report
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New Mexico Environment Department
Surface Water Quality Bureau

RED RIVER GROUNDWATER INVESTIGATION

FINAL REPORT

FUNDED IN PART BY A 319(h) GRANT FROM USEPA

PROJECT 92-A

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NEW MEXICO ENVIRONMENT DEPARTMENT
SURFACE WATER QUALITY BUREAU

March, 1996

RED RIVER GROUNDWATER INVESTIGATION

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I. INTRODUCTION

This report presents the findings of a project funded in part by U.S. Environmental Protection Agency, Region VI, under Section 319(h) of the Federal Clean Water Act. The project was conducted between June 1993 and December 1995 by the New Mexico Environment Department (NMED), Surface Water Quality Bureau (SWQB), Nonpoint Source Pollution Section. The organizational structure for this project is shown in Table 3. The technical staff member directly responsible for carrying out this project and preparing this report was Dennis Slifer. Michael Coleman assisted with completion of this project during 1995 with field work and preparation of data and figures, and was in charge of the anoxic drain BMP installation. Other staff members and programs at NMED have also been involved in environmental investigation activities within the Red River watershed during the period of this project. Field work, data, reports, and regulatory actions have been coordinated and shared between the Ground Water Quality Bureau (Karen McCormack), the Superfund Oversight Section (Stuart Kent), the Underground Storage Tank Bureau (Tony Moreland and Chris Holmes), the Point Source Regulation Section of SWQB (Richard Powell), New Mexico Office of Natural Resource Trustee (Steve Cary, Randy Merker, and John Pfeil), and a related 319(h) grant (Mineral Extraction Impacts, FY-91) within the Nonpoint Source Pollution Section of SWQB (Bob Salter). The author acknowledges the assistance of these colleagues, with special thanks to Bob Salter, Michael Coleman, Karen McCormack, and Stuart Kent for help in the field and sharing ideas. Portions of Sections I, II, and IV of this report are adapted from reports by Salter and Kent. The manuscript was reviewed by Michael Coleman, Steve Cary, Brian Wirtz, Jeff Lewellin, Jim Piatt, Stuart kent, Karen McCormack and Kim Edlund.

1.1 OBJECTIVE

The objective of this project is to determine groundwater quality and aquifer characteristics along the impaired reaches of the Red River in order to identify, and ultimately eliminate, impairment of both the aquifer and the designated uses of the river. Additionally, demonstration projects to treat contaminated groundwater seepage are intended to show feasibility of remedial technologies, and other best management practices are recommended for consideration in future restoration efforts in the Red River watershed.

1.2 PROJECT LOCATION AND DESCRIPTION

The Red River watershed, covering an area of 226 square miles, is a major tributary to the Rio Grande and begins as headwaters originating from the highest terrain in New Mexico. The east or main fork of the Red River begins at nearly 13,000 feet as springs just east of Wheeler Peak. The Red River has 21 perennial tributaries which originate as very high quality mountain streams.

The location of the Red River watershed and the major areas of activity for this project are shown in Figures 1 and 2. The Red River watershed lies entirely within Taos County in northern New Mexico. Approximately 90% of the watershed is under management of the US Forest Service (USFS), Carson National Forest, and includes two wilderness areas (Wheeler Peak and Latir Peaks) and a wilderness study area (Columbine-Hondo). Elevations range from 13,161 feet at Wheeler Peak (highest point in New Mexico) to 6,500 feet at the confluence of the Red River and the Rio Grande. The USFS high country consists of the Taos Range of the Sangre de Christo Mountains, while the lower elevations of the watershed occur on the Taos Plain and are a combination of private lands and federal Bureau of Land Management (BLM) lands. The lowest four miles of the Red River flow through a spectacular canyon that is part of the BLM-managed Wild and Scenic River Area, which includes the Rio Grande Gorge. The only towns within the watershed are Questa (population 800) and Red River (population 400). At 8750 feet elevation, Red River is the highest incorporated town in New Mexico.

The region is semi-arid, but the elevational range accounts for large variations in temperature and precipitation. Annual precipitation varies from 8 to more than 20 inches, and winter temperatures range from -25 to 50 degrees F, with summer ranging from 30 to 90 degrees F. From May to October the moisture occurs as rain or hail, except in higher elevations where snow may occur throughout the year.

The Red River occupies one of the most popular multiple use watersheds in the state. The upper portion of the watershed is a mountainous area devoted to recreational activities, chiefly skiing, hunting, and fishing, along with livestock grazing by U.S. Forest Service permittees. Prior to the early 1970s, the Red River watershed had no major industrial facilities or urban development. Since 1966 both industrial and urban developments have increased significantly. Accordingly, there has been a decrease in the quality of water resources, primarily in the middle reach of Red River, from Bitter Creek to Lama Canyon. Concerns pertaining to heavy metals, low pH levels, biological toxins, septic tank effluent, municipal sludge, and petroleum product discharges have been documented in this once pristine watercourse.

In "Water Quality and Water Pollution Control in New Mexico, 1992", it was reported that the State Water Quality Control Commission (WQCC) had listed the Red River as a stream in which designated uses were not being attained due to various types of impairment. Section 2-119 of the Red River (from mouth of Red River upstream to the mouth of Placer Creek) fails to support the designated uses of cold water fishery, irrigation, and livestock and wildlife watering. The portion of the Red River in segment 2-120 (Red River upstream of Placer Creek, and all tributaries of Red River) does not support its designated uses of high quality cold water fishery and domestic water supply. This impairment is derived primarily from nonpoint sources of pollution. For a summarized history of documented impairment of the Red River see Tables 5 through 8.

There are currently three NPDES-permitted point sources with a total of six outfalls (Figure 3) discharging into the Red River: the Town of Red River waste water treatment plant (WWTP), the State trout hatchery below Questa, and four NPDES-permitted outfalls for Molycorp Mine (two at the tailings impoundments and two at the mine site). Only the WWTP discharges upstream of the most impaired segment of the Red River, and its effluent is described as excellent quality. The hatchery discharge is return-water from the raceways and actually serves to improve water quality in the Red River due to its dilution effect. The Molycorp discharges are regulated under NPDES Permit Number 0022306, which was approved by EPA in September 1993 (on file at NMED SWQB). These discharge points are described briefly as follows:

> Discharge Point 001: from Pope Lake in the tailings dam area. There has been no discharge reported here since the mining operation ceased in 1992.
>
> Discharge Point 002: from the seepage collection system at the toe of tailings dams. This discharge is monitored and sampled as required in the permit. There have been no exceedances of specified concentration limits.
>
> Discharge Point 004: Stormwater runoff from the mine area at the Goathill Gulch drainage (effectively, the area below the caved area). No discharges have been reported by Molycorp since the permit was approved in 1993.
>
> Discharge Point 005: Stormwater runoff from the mine area in the vicinity of the mill, including drainage from Spring Gulch. No discharges have been reported since 1993.

Nonpoint sources (Figure 3) that are thought to be impacting the Red River include mining sites (primarily Molycorp, and to a lesser extent old gold mines and milling sites located in the Red River tributaries of Bitter Creek, Placer Creek, and Pioneer Creek); naturally occurring, highly erosive and acidic soils in mineralized areas known as hydrothermal alteration scars; septic tank leach fields in the alluvial valley bottoms above the Town of Red River; unlined sewage lagoons for the Village of Questa; three known leaking underground petroleum storage tanks in the Town of Red River; and sediment from steep, bare slopes at the Red River Ski Area and from many dirt roads, grazing allotments, and scar areas on the Carson National Forest.

Private lands adjacent to the Red River above the Town of Red River are intensely developed with hundreds of summer homes having individual septic tanks. Within the Town of Red River, three leaking underground storage tanks have been documented, and at least one has released gasoline to the river. Red River Ski Area, located immediately adjacent to the town and the Red River, is affecting surface water in the Red River and Pioneer Creek. Steep, bare slopes with no erosion controls are a continuous source of sediment to the river during non-winter months. Below the Town of Red River, the Molycorp (Questa) Mine has a long history of more than sixty tailings spills (most of which entered the Red River) during the operational life of the mill. Although originating as point sources (slurry spilled from broken pipelines), the tailings were spread over significant areas of the Red River floodplain, and continue to act as ongoing nonpoint sources of pollution when dispersed and transported by runoff and floods. There is documented groundwater pollution from seepage from the Molycorp tailings ponds at Questa. Acid rock drainage from sulfide-rich scar areas and a number of large Molycorp mine waste piles in the canyon above Questa contaminates both groundwater and the Red River where many perennial acidic seeps emerge. Of all the above listed nonpoint sources of pollution potentially impacting the Red River, Molycorp Mine is by far the most significant, and as such has received proportionally greater scrutiny in this investigation.

As a gaining stream, the Red River is recharged throughout the length of its main stem by groundwater, as documented by the US Geological Survey and the NM State Engineers Office. As point sources of contamination come under better control, it becomes more apparent that nonpoint source contaminants contained in groundwater recharge are contributing to the continuing impairment of this river.

Human health implications and ecological damages from these sources of pollution are currently being evaluated. The NM Office of Natural Resource Trustee (ONRT) has recently contracted for a natural resource evaluation for the Molycorp-Red River area. Contamination of private wells by tailings seepage was documented by NMED, and in 1976 Molycorp provided alternative drinking water to those residents by connecting them to the Questa Community Supply system. The town of Questa has two community supply wells, both screened in the Santa Fe Formation aquifer, located approximately .5 miles northeast of Questa and serving approximately 800 people. No current drinking water intakes from the Red River have been identified; however, fisheries and sensitive environments are both present. The Red River Fish Hatchery produces approximately 11,000 lbs. of fish per year which are used to stock the Red River above and below the Molycorp mine site and the Rio Grande. One sensitive environment affected by impaired water quality in Red River is the federally designated Wild and Scenic River area which begins near the confluence of Red River and Rio Grande. Habitat for the Southwest Willow Flycatcher, which is under review for its federally endangered or threatened status, has been tentatively identified along the Red River (USFWS, 1992).

1.3 PREVIOUS INVESTIGATIONS

In 1966, in response to the Molycorp Mine open pit development and an enlarged milling and tailings transport system, the U.S. Department of Health, Education and Welfare (HEW), Federal Water Pollution Control Administration (predecessor to the EPA) conducted a baseline water quality survey of the Red River. While effects from numerous small mining sites adjacent to the Red River and tributaries included periodic elevation of metal concentrations leached from sulphide-rich waste rock or tailings during storm events, the overall quality of the river, including the segment adjacent to the Molycorp mine site, was determined to be of high quality (USDHEW, 1966). Although the report based on this survey indicated some minor impairment of biotic support capacity by 1966, overall it still rated the Red River as an "exceptional" high quality surface water resource. In its report "Water Quality Survey: Red River of the Rio Grande, New Mexico", HEW concluded in part II-1 that:

1. The chemical quality of the Red River is exceptional....
2. Biological conditions in the river are good....
3. Groundwater resources of the area are of high quality....

In November 1971 the United States Environmental Protection Agency concluded in the report, "A Water Quality Survey: Red River and Rio Grande: New Mexico," Page 3-4:

1. The chemical quality of the Red River water remains very good....
2. Biological conditions in the river are good....
3. ...occasional breaks in the [tailings] line are causing some degradation in stream quality and biota.

During this same period of the late 1960's and early 1970's, however, the New Mexico Department of Game and Fish discovered in the course of routine population studies that fish were conspicuously absent in the middle reach of Red River where thriving populations had once existed. Fish census data of 1960 indicate that approximately 572 fish per mile were estimated in the river. The 1988 fish census found no fish in this same reach (NMDGF, November 29, 1988).

In 1982 the U.S.EPA conducted a "Site Specific Water Quality Assessment" of Red River and found the stream to be substantially impaired from metal loading. This report concludes, on page 35:

1. Concentrations of ambient total arsenic, cadmium, and silver exceeded EPA-recommended acute criteria....
2. 'Control' stations...contained higher concentrations of all metals except zinc.... It is not known whether these

elevated concentrations are a result of background geologic conditions...or upstream nonpoint, mining-related, discharges to the river....

5. Bioassay results from tests with Red River water suggested some biological toxic response may be occurring in Red River.

In 1984 the BLM published results of its study of water quality in the Red River and Rio Grande between 1978 and 1983 in response to the creation of a component of the National Wild and Scenic River System (Garn, 1984). This study documented pollution sources and found a downstream increase in concentrations of various constituents, at times exceeding water quality standards, and found that the major impacts were due to mining and related activities. Nonpoint sources were found to be a major cause of elevated trace element concentrations.

Water quality concerns relating to the Molycorp site have been studied by several programs within NMED, predominantly by the Surface Water Quality Bureau, Ground Water Quality Bureau, and the Superfund Oversight Section. Point source discharges from the Molycorp tailings ponds at Questa have been monitored through a National Pollution Discharge Elimination System (NPDES) permit issued by U.S. Environmental Protection Agency. Renewal of the permit in 1993 included two additional discharge points for stormwater runoff from the mining site.

Two studies conducted by the NMED-SWQB in 1986 and 1988 confirmed high metal loading of the Red River by periodic storm events but that metal concentrations in the river and sediment were not elevated to the point of causing aquatic toxicity (Smolka and Tague, 1987 and 1989). The major elements which became elevated between the Red River Waste Water Treatment Plant and the Questa (USFS) Ranger Station were Fe, Al, Mn, and Zn. A portion of this segment abuts Molycorp property where mining operations have occurred. One conclusion drawn from these surface water surveys was that episodic run-off events erode oxidized, sulfide-rich soils from barren slopes and mining scars. This process generates acidic run-off which mobilizes and transports trace elements, including heavy metals, to the Red River. The acidic run-off temporarily reduces the pH of the river but the metals precipitate downstream as the pH becomes more neutral. Another result from these surveys was that biomonitoring in the Red River generally showed no chronic or acute toxicity but that biological indices were severely reduced below the Molycorp Mine.

During the period 1992 to 1994 a project dealing with mineral extraction impacts to water quality in the Red River (and other) watersheds was partially funded by EPA Region VI under CWA 319(h) and was carried out by SWQB (R. Salter, project manager). Some of the activities of that project, by necessity, overlapped with similar activities of this current project, and field work and data were shared. The current project is distinguished by an emphasis on groundwater NPS sources as they impact the Red River. The sampling and monitoring efforts undertaken by SWQB since 1992 under the Mineral Extraction Impacts (MEI) project are not intended to establish a statistically valid trend documenting degraded conditions. The progressive degradation of the Red River has been established for many years and has been reported by the Water Quality Control Commission (WQCC) and the SWQB in the 1986, 1988, 1990, 1992 and 1994 305(b) reports to Congress (see Tables 5 to 8). The 1992 305(b) report listed an increased concentration in Red River in the vicinity of Molycorp Mine of several metals including Cd, Cu, Pb, Ag, and Zn. The 1992-94 MEI project was intended to provide a snapshot of the chemical makeup of the entire watershed under a variety of conditions in order to provide a general water quality profile of the tributaries and mainstem. SWQB continues to actively document the effectiveness of land management adjustments to restore chemical and biological integrity to this watershed.

A number of other previous investigations of water quality (primarily groundwater) in the watershed that focused on the Molycorp facilities have been generated by the regulatory involvement of NMED Ground Water Quality Bureau (GWQB). During 1987-90 Molycorp was proposing to build a new tailings impoundment area in the Guadalupe Mountain saddle area, located on BLM lands several miles north of the existing tailings ponds. The GWQB required Molycorp to conduct a number of hydrogeologic studies of the area as part of the requirements for a Ground Water Discharge Plan. These studies, by a number of consultants, characterize the geology, groundwater hydrology, geochemistry, and other factors for the region lying between the Red River, Rio Grande Gorge, and the mountain front at Questa (Dames and Moore, 1987 and 1988; Molycorp, April 1987; Vail Engineering, December 29, 1988; GWQB files). Molycorp never built the proposed new tailings facility because the mine operations ceased in 1992. In 1993 the GWQB required Molycorp to submit applications for Ground Water Discharge Plans for two areas believed to be contaminating ground water - the tailings impoundments and the mine waste-rock dumps. Again, a number of water quality investigations were generated at Molycorp as a result of this regulatory activity. A decision was made by GWQB in 1994 to require Discharge Plans for the tailings area (DP-933) and the mine waste rock piles (DP-1055). Much historical and current baseline data and information for both sites have been collected by Molycorp consultants and by the GWQB as part of these processes (South Pass Resources, July 14, 1993, Jan. 28, 1994, March 4, 1994, April 21, 1995; Vail Engineering, July 9 and September 24, 1993; Steffen, Robertson and Kirsten, April 13, 1995; NMED, GWQB and SWQB files). The site investigation and monitoring process is ongoing, particularly at the mine area, as dictated by Discharge Plan requirements.

During 1995 negotiations began with a series of meetings between Molycorp and the NMED programs that have statutory authority there to discuss entering into an administrative order on consent (AOC) that would guide future remedial work at Molycorp. Following several meetings this process stalled and is currently being reviewed by legal staff.

The U.S. EPA Superfund program (Region VI, Dallas, TX) conducted a Preliminary Assessment of the Molycorp site in May, 1980 and a Site Inspection in June, 1981. The conclusions of these reports, respectively, were for no further remedial action and placing the site at a lower priority. However, EPA funded field investigation teams (FIT) to investigate Molycorp in 1983 and 1985 (EPA Site Inspection Report, NM 00558, August 19, 1983; Ecology and Environment, June 4, 1986). Part of these investigations was an assessment of the Molycorp waste disposal area ("landfill") located near the head of Spring Gulch (above the mill area). This landfill was described as actually a mine rubble pile more than 100 feet thick that was used as a boneyard for discarded equipment and parts. Some unrinsed reagent drums from the mill were the only "hazardous" wastes observed. Soil samples were collected and analyzed for metals and organics in both investigations of the area, but were inconclusive, in part because appropriate background soil samples were not collected for comparison (for more detail see discussion of results in Section 2.3.1.1). The 1983 investigation concluded that the "opportunity for surface or ground water contamination was very low". The 1985 inspection observed a small oil spill (not sampled) and commented that the area was still active as a dump for empty drums and old equipment. Conclusions from the second investigation included the recommendation for further study of this landfill under RCRA authority. Molycorp has had two landfills (in Spring and Goathill Gulches) which are exempted from NM Solid Waste Management Regulations since they received only demolition and construction debris. The Spring Gulch site is inactive, having been covered with several hundred feet of overburden during subsequent mining operations that filled Spring Gulch (personal communication with D. Shoemaker, mine manager, 1993).

A Screening Site Inspection (SSI) was conducted by the NMED Superfund Oversight Section (under contract to U.S. EPA Region VI) for the Red River Mining District in 1989 (NMEID, August 31, 1989). This investigation evaluated the old mines (gold, silver, molybdenum, lead, and copper) located along the Red River and tributary headwaters, along with several small milling and smelter sites which operated between 1867 and 1900. The report concluded that, although some environmental impacts were present (acid rock drainage, elevated metals concentrations in wastes or soils, etc.), the old mining district site does not qualify for the National Priorities List (NPL, or Superfund).

The NMED Superfund Oversight Section initiated further CERCLA regulatory activities for the Molycorp Site in 1993 with the preparation of a Hazard Ranking System (HRS) Screen (NMED, August 13, 1993). That report evaluates Molycorp using the revised HRS (12/14/90), to determine if the site could potentially be listed on the National Priorities List. Subsequently, NMED Superfund initiated an Expanded Site Inspection (ESI) for the Molycorp site (includes the mine, waste rock dumps, and tailings impoundments). An ESI Workplan (NMED, Feb. 28, 1994) was approved by EPA in March 1994, and field work/sampling for the ESI was conducted on two occasions during 1994 (in coordination with similar activities by this project). The Superfund/CERCLA process is ongoing at the Molycorp site for the foreseeable future. The ESI Report was submitted to USEPA October 23, 1995.

Among the more significant preliminary results from the recent investigations by NMED Superfund and SWQB are observations and sampling of the acidic seeps along Red River below Molycorp. During shared field reconnaissance by this project and Superfund, water from groundwater seeps was observed emerging and entering Red River approximately one and a half miles below (southwest) Molycorp mine. Along this same stretch of the Red River, manganese concentrations were greater than three times the concentrations detected upstream (NMED, Feb. 28, 1994, Table 6; Smolka and Tague, 1989). The concentrations of zinc and total aluminum were two to three times greater than background. Other reports have determined that there is a general increase in the loading of sulfate, manganese, zinc and aluminum in the downstream direction, with those seeps located below Capulin Canyon being the major contributors (Vail Engineering, July 9, 1993).

During 1994 another, newly created, state agency became involved in regulatory investigations at the Molycorp site. The NM Office of Natural Resource Trustee (ONRT) is investigating natural resource damages from Molycorp in the Red River area, and has participated in sampling activities and review of Molycorp reports and workplans. A natural resource evaluation is being conducted.

During 1995 staff from the SWQB, Nonpoint Source Pollution Section were instrumental in initiating the formation of a Red River Watershed Association. Meetings have been held in the Town of Red River and the Village of Questa, with attendance and participation by interested citizens, state and federal agencies staff, environmental groups, and municipal representatives. It is hoped that this group will continue to play a role in management of the watershed for water quality protection.

Also during 1995 the Molycorp Mine became involved in the permitting process that is required by the recent New Mexico Mining Act (administered by the NM Mining and Minerals Division). NMED staff reviewed and commented on Molycorp's Site Assessment and Permit Application, made site inspections, and attended a public hearing in Questa in September, 1995. A site closure plan is required by the Act, and will be submitted in early 1996.

II. RED RIVER WATERSHED

2.1 DESCRIPTION OF WATERSHED AND WATER QUALITY ISSUES

2.1.1 SURFACE WATER HYDROLOGY

The Red River watershed, covering an area of 226 square miles, is a major tributary to the Rio Grande and begins as headwaters originating from the highest country in New Mexico. The Red River has 21 perennial tributaries which originate as very high quality mountain streams. Those tributaries that do not have major concentrations of mining remain high quality streams up to their confluence with Red River.

Cabresto Creek is the largest tributary to Red River, having a drainage area of 36.5 square miles and an average discharge of 14 cfs, or 10,135 acre-feet/year (af/y). The average annual discharge of Red River, excluding Cabresto Creek, is 55.9 cfs, or 40,500 af/y. The upper Red River (above Zwergle Dam) has a drainage area of 29.42 square miles and discharges 17.7 cfs, or 12,820 af/y as an average (Dames and Moore, April 19, 1988). A number of seepage studies have demonstrated that the Red River is a gaining stream in the vicinity of both the Molycorp tailings area and mine area. The lower reach of the Red River (from Cabresto Creek to mouth of Red River) has been measured having an average accretion rate (seepage of groundwater) of 31 to 33 cfs out of a total flow of 84 cfs at the mouth of Red River (Winograd, 1959, p.40). In the middle reach of the Red River (the reach from Red River to Questa, which includes the Molycorp mine area) seepage studies have documented accretion from groundwater into Red River at average rates of 4 cfs (USGS, Oct. 1988).

The US Geological Survey has been measuring discharge and collecting water quality samples at various points on the Red River for over twenty years. Published data is available from their Water Resources Data Book for New Mexico for discharge, field parameters, anions/cations, and trace elements the following years: 1964-65 and 1969-1967 at the Fish Hatchery; 1978-1982 at Zwergle Dam, Molycorp Mine, Questa, Fish Hatchery, and mouth of Red River; 1983-87, at Questa, Fish Hatchery, and mouth of Red River. There is no data available for the period following 1987.

The drainage system of the Red River is controlled by the former radial dispersion of mountain glaciation from the Wheeler Peak and Gold Hill areas, as well as by fault patterns created during Miocene deformation. These effects are vividly displayed by the counter-clockwise course of the Red River (Clark and Read, 1972). The profiles of side streams tend to be short and have steep gradients. The structural Red River graben element (described further in Section 2.2) is drained by the lower part of the Red River and Cabresto Creek, both of which are structurally controlled. Drainage patterns are similar to those in the Taos uplift, and locally a trellis pattern predominates. The hydrothermally altered scar areas that occur along the north side of the main stem of Red River are so easily eroded that mudflows are produced by heavy precipitation, creating debris aprons where tributaries enter Red River. Past major mudflows have at times dammed Red River, creating temporary lakes and meadowlands that have led to pronounced gradient changes in the stream profile (former dammed-up areas are now flatter spots, such as the location of the town of Red River, Forest Service Campgrounds west of Red River, the Molycorp mill site, etc.). Gradients in debris apron regions are in excess of 0.028, whereas gradients in regions between debris aprons are generally lower (Meyer and Leonardson, 1990).

Background or source water pH values within the Red River watershed range from 6.94 to 8.04, and conductivity values range from 114 to 177 umhos/cm. With exceptions, metal concentration values at these source waters are below detection limits and well below State standards. At the headwaters stations all metals except magnesium are below detection limits. Magnesium at these stations is generally well below 2.0 mg/l (NMED-SWQB, Jan. 1995). Source water samples collected from Columbine Creek contained both chromium and lead at levels just above detection limits but within State standards. Bitter Creek's source waters contain chromium at similar levels. In both cases however, analytical results of subsequent same-day samples of the middle reach of these tributaries found all metals tested for were below detection limits. In the two roadless tributaries (East Fork of Red River and Columbine Creek) there are no significant changes in water chemistry up to their confluence with Red River. In fact within these tributary reaches there is a subtle increase in alkalinity and pH and a reduction in total dissolved solids (TDS) and conductivity.

Most of the mining in this watershed is concentrated in seven tributaries and in the middle reach of the mainstem of the Red River. Cabresto Creek drainage, with the exception of a few minor old prospects and mines, is free of mining impacts and associated water quality problems. Acid rock drainage (ARD) from a number of small mines on other tributaries to Red River (Bitter, Placer, Pioneer, Black Copper, Goose, and Bear Creeks) and from the Molycorp complex of waste dumps, underground mines, and open pit constitute the worst sources of metal loading in the Red River watershed. This ARD commonly exhibits pH values at or below 3.0 and conductivity over 3500 umhos/cm. This drainage is also characterized by very high values for total dissolved solids (TDS) and sulfates. Acidic metal-loaded seep waters collected from a variety of sources throughout the watershed show a range of pH values from 2.44 to 3.22 and a range of conductivity values from 1769 to 3668 umhos/cm. Those metals found in typical acidic seeps along Red River that exceed state standards include Al, Fe, Mn, Co, Cu, Ni, Zn, and Cd (Table 1). In the three tributaries where most of the historic mining has occurred (Bitter, Pioneer, and Placer Creeks), there is a slight, but detectable increase in metal loading at base flows. The metals that show detectable increases are primarily aluminum, zinc, manganese, and magnesium. Obviously associated with this increase in metals is a slight increase in TDS and conductivity, however, the volume of ARD from these locations is quickly diluted by alkaline receiving waters. Metal loading in base flow conditions is not a serious problem until the mainstem of Red River encounters the five square miles (3,200 acres) of mining-related disturbance at the Molycorp mine operation twelve miles above the confluence of the Red River and the Rio Grande. The reach of Red River from just below the Molycorp mill to the Red River Fish Hatchery (a distance of approximately eight miles), has been adversely affected by pollutants, resulting in biological impoverishment. The primary reason for this current condition is an infusion of acidic, metal-loaded seep waters in such volume that it overwhelms the river's natural buffering capacity. As a result, the river in this reach is a pale-blue or milky-white color due to metal ions and minerals (primarily silica-aluminum hydroxide) precipitating out of solution. Mineral deposits precipitated in this reach have cemented the stream substrate thus limiting potential for benthic community colonization and development.

2.1.2 CONTAMINANT TRANSPORT

There are two general modes of contaminant transport at work in the hard rock mining districts of the Red River watershed; steady-state, or perennial form of ARD, and the pulse loading mode in which sometimes very large volumes of weathered sulfide waste rock and sediment are transported to stream channels by storm events and rapid snowmelt. These two principal mechanisms are addressed as separate but related issues.

The steady-state form of contaminant transport has received the most attention from researchers since its full pollution potential was first recognized. The earliest work in the U.S. in regard to this problem was carried out in the Appalachian coal fields. Further research into this form of water pollution has been carried out in the last twenty years in the Rocky Mountain region, much of it in response to widespread degradation of the Arkansas River in Colorado and a 120 mile reach of the Clark Fork River in Montana. In both cases the stream degradation originates in hard rock mineral extraction and processing areas. The mechanisms of ARD formation and its effects on aquatic ecosystems are well known. ARD is characterized by low pH and elevated concentrations of metals and TDS. The most common mechanism for its formation involves the oxidation and hydration of sulfide minerals (typically pyrite, or iron sulfide), resulting in the generation of sulfuric acid and elevated concentrations of iron. A number of promising passive treatment technologies have emerged from the study of this phenomenon in recent years (see Sections 4.2 and 4.3).

The pulse loading mode of pollution from hardrock minesites is less well understood and can be more difficult to control. Field investigations and laboratory experiments have proven that pulse events not only transport large volumes of mine waste through direct erosive processes but also through solution facilitated by reduction in pH. The suspended metal load from a pulse event may fall out within a relatively short distance, but the dissolved metal load may be transported for many miles before pH conditions allow precipitates to form. In either case, the pulse loading mode of mine waste transport is the primary mechanism by which these contaminants are moved far from their origins.

Pulse loading of sediments and dissolved constituents is a significant problem in the Red River and several of its tributaries. The SWQB Standards and Surveillance Section has documented a rapid decrease in pH and increase in turbidity in the mainstem of the Red River just below a tributary above Fawn Lakes Campground (Hansen Creek) in response to a summer rain event. Analysis of water samples collected during this pulse event proved that metal loading also increased dramatically (Smolka and Tague, 1988). This tributary contains a large hydrothermal alteration scar that may have been exacerbated by erosion triggered by mineral exploration roads and at least one mine. The weathered sulfide materials exposed in large erosional scars in a number of locations within the Red River watershed do react rapidly with distilled water. Preliminary data from simple laboratory reactivity tests conducted by NMED staff using wastes from mines and soils from erosional scars have reproduced field pulse conditions and verified the rapid reduction in pH and increased turbidity. Subsequent X-ray Fluorescence (XRF) analysis of the soils and mine wastes used in these reactivity tests found higher levels of metals in mine wastes than in soils collected from erosional scars (SWQB files, personal communication B.Salter, 1993). Of the 21 perennial tributaries to the Red River only two, Columbine Creek, and the Upper East Fork do not contribute significant amounts of sediment in response to pulse events. Both of these sub-watersheds are roadless, have no mining activity, and do not contain alteration scars.

In response to pulse events such as snow melt or intense summer rainstorms, the Red River becomes seriously degraded from sedimentation. Much of this sediment load originates in large, barren erosional scars caused by slope failures in at least fifteen locations within the middle reach (Figures 3 and 4). Some of these slope failures may be related to human influences such as small mine and mineral exploration roads (for more information on scars see Section 2.3.2). Also, an extensive system of forest roads, mineral exploration roads, tracks, and off-road vehicle trails erode and convey significant amounts of sediment to the Red River. The negative influence of these sedimentation episodes is mainly temporal. However, the effect on water quality and the dependent biotic community during these events is dramatic. The sediment loading problem in the Bitter Creek tributary is especially severe, and is being addressed by a separate 319(h) grant (Lower Bitter Creek Restoration, FY-94-B) which the SWQB has recently implemented

Of the two dominant mechanisms of contaminant transport at work within the watershed, the steady-state mode is of primary interest in this investigation because it involves the perennial, base-flow seepage of acid drainage that affects groundwater, and it is the impact of contaminated groundwater on the Red River that is of interest here.

2.1.3 CATEGORIES OF NPS POLLUTION IN THE WATERSHED

Metals

Metal loading of the Red River is the most widespread and significant form of NPS pollution in the watershed. The primary metals involved in contaminant transport, discussed previously, include; aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, and zinc.

The primary cause of metal loading in the Red River is by steady-state input of acidic, metal-enriched seep water. This first appears at the mouth of Bitter Creek and again in small volumes from several small drainages between The Town of Red River and just below Hansen Creek. From below Molycorp Mill to the Questa Ranger Station, a series of acidic, metal-loaded seeps appears to overcome the river's natural buffering capacity. From that area downstream to the Questa Fish Hatchery, the Red River appears to be largely devoid of many biotic communities.

Secondly, pulse event loading of acidic, metal-laden water is of concern. During and after pulse events, metals are transported from various source areas at high concentrations in both the suspended load and in the dissolved fraction of the water column. (Smolka and Tague, 1986, 1988). Metal loading problems associated with pulse events are largely temporal. In most cases, a degree of equilibrium is restored to affected stream reaches within a day or so after a major pulse event. Short-term biological impacts may however be significant due to exceedances of acute criteria. If high enough concentrations are reached, lethality is possible. Therfore even short term effects can cause long term biological impacts.

Sediment

Sediment transport in the middle reach of the Red River during pulse events is extreme - turbidity values in excess of 1000 NTU are typical. Distinctive plumes of yellow-orange turbidity transform the Red River to its confluence with the Rio Grande, and similarly affect the Rio Grande for at least fifty miles downstream (NMED-SWQB field notes, August 1994). The primary source areas for sediment loading are the alteration scars plus unpaved roads in the watershed. As well, Pioneer Creek has been documented as exceeding turbidity standards on several occasions due to ski area runoff. (Those problems have been addressed in part by a separate 319(h) grant [Ski Area Impacts, FY-91] through the SWQB). Sediment transport from the sub-alpine components of the watershed is also a significant problem. Within these areas, the excessive road network and riparian loss due to historic grazing practices are primary causes of sediment loading.

Nutrients

Nutrient loading has not been documented as a water quality problem. There is however, evidence that nutrients may be increasing in summer sub-alpine grazing areas, and adjacent to housing developments above the Town of Red River. Dense algal mats have been observed in stream reaches adjacent to these developments, possibly in response to elevated nutrients concentrations (see Section 2.3.4).

2.2 GEOLOGIC AND HYDROGEOLOGIC SETTING

A geologic map of the Red River watershed is shown on Figure 5. The majority of the Red River watershed, including Molycorp mine, is located in the Taos Range, which is made up of intrusive igneous (granite) rock and metamorphic (amphibolites, quartzites and schists) rocks of Precambrian age which are overlain by Tertiary volcanics (Roberts et. al., 1990; Gustafson, 1966). The latter consists of flows, breccias and tuffs of andesite, latite and rhyolite. A series of thrust faults (trending N) and high angle faults (trending N to NW and E to NE) lead to the downfaulted area of the Molycorp mine site. Subsequent intrusion of granite stocks (Late Tertiary) caused fracturing and brecciation primarily along zones of contact with older rocks. Propylitization of volcanics surrounding the granite stock and hydrothermal alteration along brecciated zones caused the emplacement of molybdenite and other minerals in the granite near the contact with the propylitized rock (USDHEW, 1966). The down-faulted area referred to above is part of the Red River graben, a negative structural feature that consists of jumbled and tilted fault blocks aligned in an east-northeast direction, and stretching from near the western margin of the Sangre de Christo Range near Questa to the Midnight-Anchor Mines area at the head of Bitter Creek (fourteen miles in length and two to four miles wide). The major fault line along the graben follows the line of the Red River and Bitter Creek, although it is almost completely concealed by alluvium and mudflow. North of the Red River fault a line of hydrothermal alteration scars marks a parallel fault (see Section 2.3.2). The graben is segmented by a series of northerly striking faults, making a very complex structure (Clark and Read, 1972).

A useful conceptual model of the groundwater aquifers believed to be present in the middle reach of the Red River and at the Molycorp mine area consists of three distinct units for characterizing groundwater there: 1. groundwater which flows through fractures in the hard rock formations; 2. groundwater within the alluvial sediment of the Red River channel or; 3. groundwater within the alluvium of the side channels (tributary drainages). Separation of the groundwater flow into three systems is useful in understanding general hydrogeology near the mine site and assists in defining sources for the seeps near the Red River. It does not, however, necessarily preclude communication among systems. The placement and screening of twelve new monitoring wells drilled in the Molycorp mine area in 1994 was determined based on the model given above (Appendix C). Based on initial observations of these wells in 1994, groundwater flow velocities in the mine area (in all the units) are thought to be on the order of 50 to 500 ft/yr; gradients are up to .026 ft/ft (the steepest observed); and flow direction is to the southwest (toward the river) (J. Kepper, personal communication, Nov. 1994).

Five miles to the west of the Molycorp mine, the Village of Questa is situated on the Taos Plain, in the Rio Grande Basin, which resulted from Miocene uplifting of the Taos Range (Gustafson, 1966; Winograd, 1959). This downfaulted area has received alluvial sediment from the Taos Range. Intermittent extrusion of lava during late Pliocene and early Pleistocene resulted in interbedding of the lava with alluvium. These lithologies together with occasional lake deposits comprise the Santa Fe group.

The Santa Fe Group is the major water-bearing unit in the Rio Grande Basin of Taos County (Winograd, 1959, p. 15). Depth to water in the Questa area is generally in the range of 60 to 160 feet. Gradients range from only a few feet to 100 feet per mile. Groundwater flow near Questa and the tailings ponds is generally southwest, away from the mountains, and recharges the Red River and Rio Grande by numerous springs which generally emerge from the basalt layer. Those springs which recharge the Red River are located southwest of the tailings ponds toward the confluence of the Red River and Rio Grande. Some of these springs are hydrologically connected to the waste water leaching through the tailings ponds (Vail Engineering, Sep. 24, 1993).

A number of seepage studies have demonstrated that the Red River is a gaining stream in the vicinity of both the tailings area and the mine area. The lower reach of the Red River (from Cabresto Creek to mouth of Red River) has been measured having an average accretion rate (seepage of groundwater) of 31 to 33 cfs (Winograd, 1959, p.40). In the middle reach of the Red River (the reach from the Town of Red River to Questa, which includes the Molycorp Mine area) seepage studies have documented accretion from groundwater into Red River at an average rate of 4 cfs (USGS, Oct. 1988).

2.3 GROUNDWATER NONPOINT SOURCES OF POLLUTION FOR RED RIVER

The list of potential nonpoint sources of groundwater pollution that are thought to be impacting the Red River include mining sites (primarily Molycorp Mine and tailings impoundments, and to a lesser extent old gold mines and milling sites located in the Red River tributaries of Bitter Creek, Placer Creek, and Pioneer Creek); naturally occurring, highly erosive and acidic soils in mineralized (scar) areas; septic tank leach fields, leaking underground storage tanks, and Questa's sewage lagoons. Several other nonpoint sources of pollution previously mentioned (tailings spills at Molycorp and sediment eroded from various sources) primarily affect Red River water quality via direct surface runoff rather than through seepage of contaminated groundwater. Therefore these nonpoint sources receive minimal discussion in this section.

While the cumulative impacts to Red River water quality from all of these NPS sources cannot be ignored, the single greatest impact is due to metal loading and associated pH changes related to acid rock drainage from mining activities and scar areas. The discussion of groundwater NPS sources that follows is prioritized accordingly.

The Red River watershed is one of the most severely impacted perennial stream system in regard to metal loading in New Mexico. The mainstem of the Red River is also among the most intensively studied stream reaches in New Mexico (see Section 1.3). In April of 1992, NMED began comprehensive documentation of the sources of metal loading in the upper watershed of Red River. Many of the smaller mine sites in this watershed are located on public lands within the Carson National Forest. However, the largest sources of metal loading within this watershed (Molycorp and other mine sites) are located on private patented inholdings removed from the public trust under provisions of the General Mining Law of 1872.

Upstream of the Molycorp Mine site the contribution of metal-loaded drainage is handled without apparent serious impact by the natural buffering and dilution capacity of the Red River. However, beginning at the vicinity of Molycorp Mine and Mill, the volume of metal-loaded drainage seeping out of the waste rock piles, scar areas, open pit, and the underground workings overwhelms the river and has significantly degraded water quality and biological integrity for at least eight miles to a point just below the Red River Fish Hatchery.

2.3.1 MINING-RELATED SOURCES

Those tributaries that do not have major concentrations of mining sites remain high quality streams up to their confluence with the

Red River. Most of the mining in this watershed is concentrated in seven tributaries and in the middle reach of the mainstem of the Red River. Effects from numerous small mining sites adjacent to the Red River and these tributaries include periodic elevation of metal concentrations leached from sulfide-rich ores during pulse events. Metal loading from ARD in base flow conditions is not a serious problem until the mainstem of the Red River encounters the Molycorp mine operation. At least eight miles of Red River from Molycorp to the Red River Fish Hatchery is essentially a biologically dead reach. This zone of the Red River is due primarily to continual metal loading from seeps issuing from a number of locations along a six mile section of the middle reach, beginning below the Molycorp Mill and persisting until about the Questa Ranger Station.

2.3.1.1 MOLYCORP MINE AND TAILING AREAS

The Molycorp operation is a molybdenum mine, mill, and tailings disposal site, and has been inactive (on standby status) since 1992. It is currently under review by several regulatory programs within the New Mexico Environment Department (NMED), including the Superfund Oversight Section, which is determining whether the site is a potential candidate for inclusion on the National Priorities List (NPL). See pages 8 and 9 for a more complete description of Superfund activities at Molycorp Mine.

The mine, surrounded by Carson National Forest, occupies approximately three square miles on patented land owned by Molycorp, Inc. The mine consists of both underground and open pit operations. The tailings ponds occupy approximately 1 square mile and are located 1 mile west of Questa on land owned by Molycorp Inc., and consist of two large ponds and one smaller pond. A series of pipelines transport the tailings in a slurry from the mill site to the ponds.

Mining History of Molycorp

Molybdenum Corporation of America (MCA) acquired mining rights to Sulphur Gulch in 1920 and conducted small-scale mining operations until 1923 when the mill was constructed (Figure 7). The old underground workings consisted of adits, winzes and raises which followed the irregular vein system. In 1941, a haulage adit approximately one mile long was constructed to facilitate ventilation and drainage (USDHEW, 1966, p. 6). By 1954 this underground complex contained over thirty five miles of workings at fourteen production levels ranging in elevation from 7764 to 8864 feet. By 1954 all but the lowest three working levels were designed to drain by gravity out a mile-long service portal (known as the Moly Tunnel) located above the elevation of Red River. The lower three working levels gathered drainage in a sump and this water was pumped to the service portal where it was allowed to drain by gravity to Red River. This original underground Molycorp mine continued to grow until the open pit mine was developed. In 1965, MCA switched to an open pit operation which required the transport of tailings via a pipeline approximately eight miles downstream to tailings ponds located 1 mile west of the Village of Questa (Figure 9). Tailing Dam #1 is located in Section 36 of T29N, R12E. Decant water from the associated pond was discharged to Red River via culvert tunnels through the dam. In 1969, a smaller dam was constructed north of Dam #1 with overflow weir structures to keep waste water from the dam face. Waste water was conveyed to a small holding pond (called Pope Lake) for further settling before discharge to the Red River. Molycorp referred to this discharge point as outfall #001 (now an NPDES outfall). In 1971, the second large dam (Dam #4) was constructed southwest of Dam #1 (in Section 35 of T29N, R12E) with an impermeable membrane on the dam face. Surface water diversion ditches were installed in 1974 on the north, east and west sides of the ponds to divert surface water run-on around the ponds. The following year, interceptor trenches (called seepage barriers) were constructed below Dam #1 and east of Dam #4 to collect leachate from the tailings ponds. This waste water is diverted around dwellings below the dams and discharged to Red River through NPDES outfall # 002. Several private wells located below the tailings ponds were used for drinking water purposes until Molycorp offered to switch them to the Questa community supply system after contamination from tailings seepage was discovered. This switch occurred approximately in 1976 (NMED, Feb. 28, 1994). While wells below the tailings pond are not used for drinking water purposes they still may be in use for agricultural purposes. The total population served by groundwater within four miles of the tailings ponds is approximately 2,400 (NMED, Feb. 28, 1994). In 1978, Unocal 76 Corporation purchased Molybdenum Corporation of America and shortened the name to Molycorp, Inc. Molycorp constructed an ion exchange plant near Pope Lake in 1983 to treat the waste water prior to discharge.

After extensive mineral exploration in Goathill Gulch during the 1970's and early 1980's, Molycorp ceased open pit operations in 1985 and reverted back to underground mining techniques. The recent mining activity is referred to as the new underground workings (Figure 7). Production declined significantly in 1989 due to decreased value of molybdenum and the number of employees shrank from a maximum of more than a thousand to approximately two hundred. Low production continued until 1992 when operations stopped. During the period of this project only eleven employees maintained the facility in a standby status. In 1995 Molycorp hired additional staff and resumed pumping the water that had been re-flooding the mine, and discharges this mine water via the tailings pipelines to the tailings ponds at Questa.

Waste Sources at Molycorp

A total of 328 million tons of mine waste rock has been deposited in four main drainages: Capulin Canyon, Goathill Gulch, Spring Gulch, and Sulphur Gulch (Figure 7). While the waste rock occupies a surface area of approximately 40 million square feet (NMED, Feb. 28, 1994), the bulk of it is in Sulphur Gulch where the open pit is located. No underlying liner or other containment structure for the waste rock is present. The mine waste rock consists primarily of two rock types: hydrothermally altered volcanics (andesite and rhyolite) which is yellow in color and the aplitic granite (also called soda granite) which is gray. XRF screening of two samples of mine waste rock indicated levels of copper, zinc, lead and cadmium above background concentrations (NMED, Feb. 28, 1994). Concentrations ranged from 40 ppm for cadmium to 240 ppm for zinc. Analytical data of samples from waste rock dumps and hydrothermal scars, collected by NMED Superfund Program in 1994, are used to compare concentration ratios of metals concentrations (Table 4 of Appendix A). The waste rock exhibited two to five times greater average concentrations of Mo, Zn, Cu, and Mn than scar material.

The tailings ponds, comprised of fine-grained tailings and waste water, occupy about 26 million square feet and are located behind three dams. The amount of tailings in these ponds is estimated to be 95 million tons. Only one of these dams has an impermeable liner on its face. No other liner is present but transmission of waste water from the tailings slurry to groundwater is slowed by fine-grained sediment of the waste (slimes). This waste material was characterized from split sample analysis conducted by Molycorp and the Questa Board of Education. Analytical results showed lead, copper and zinc at concentrations ranging from 90 ppm (lead) to 240 ppm (zinc). A subsequent analysis of the tailings by NMED reported lead and zinc but no copper.

The two primary waste sources of the Molycorp site (tailings dams below Questa and mine waste dumps above Questa) are located in different physiographic areas which are separated by regional block-faulting. The Molycorp mine, and associated mining waste rock, is located in the igneous and metamorphic rock of the Taos Range, whereas the tailings impoundments are located on alluvial sediments and basalt flows of the Rio Grande Basin.

A third source of waste from Molycorp exists in the remnant deposits of tailings that resulted from approximately one hundred spills from broken tailings pipelines. The tailings slurry pipeline was nine miles long; six miles of which was located only a few feet from the river. Sixty to eighty spills occurred between 1966 and 1976 (EPA Site Inspection Report, August 19, 1983). Each pipeline spill represented thousands of gallons of mill tailings slurry. Although many of these spills were cleaned up by Molycorp, some spilled into the river and have formed scattered residual deposits within the alluvium along the floodplain, where they are subject to dispersal by flooding and erosion. The distribution of these tailings deposits has not been determined (although they have been observed in the field at various locations) and concentration of metals is unquantified.

A fourth possible source of NPS contamination from the Molycorp site may be represented by the old waste disposal ("landfill") area near the head of Spring Gulch (Figure 7). This landfill was described by EPA inspectors as actually a mine rubble pile more than one hundred feet thick that was used as a boneyard for discarded equipment and parts. Some unrinsed reagent drums from the mill were the only "hazardous" wastes observed (pine oil, methyl isobutyl carbinol, etc.). Chloroethane and oils used in the flotation process were reclaimed by a registered recycler. Soil samples were collected and analyzed for metals and organics in both investigations of the area, but were inconclusive, in part because appropriate background soil samples were not collected for comparison. A distinction was not made between soil areas developed in mineralized areas and those in non-mineralized areas. Some organic compounds were detected in very low concentrations, at estimated values below the instrument detection limits, in soil sampled above the site but not below it. The 1983 EPA investigation concluded that the "opportunity for surface or ground water contamination was very low". The 1985 EPA inspection observed a small oil spill (not sampled) and commented that the area was still active as a dump for empty drums and old equipment. The Spring Gulch landfill site is inactive, having been covered with several hundred feet of overburden during subsequent mining operations that filled Spring Gulch (personal communication with D. Shoemaker, mine manager, 1993).

Although not a mining waste, the hydrothermal alteration scars present at the Molycorp mine site need to be considered when dealing with the issues of background concentrations for both solids and groundwater at this site. Major scars occur in the heads of Goathill Gulch and Sulphur Gulch, where they affect the quality of surface runoff water and the acidic springs issuing from the base of the mine waste dumps.

Hydrology of the Molycorp Mine Area

With the shift to open pit mining, the original extensive underground complex ceased to be pumped dry, and the drainage portal (Moly Tunnel) was sealed with a concrete bulkhead in 1992. The open pit was developed on top of the older underground workings. The location of the open pit naturally led to interception of various levels of the old workings as the pit developed. The accumulation of surface waters and intercepted groundwater flows in this pit did not interfere with operations because water drained out of the bench cuts and was held at least for a while in the underground reservoir of the abandoned workings. Within a year or two of the development of the open pit (1965), longtime area residents began to notice a change in the color of the Red River below Molycorp (NMED-SWQB, Jan.,1995).

In the middle reach of the Red River (from the Town of Red River to Questa, which includes the Molycorp mine area) seepage studies have documented accretion from groundwater into the Red River between Columbine Creek and Questa Ranger Station at average rates of 4 cfs (USGS, Oct. 1988). While most of the leachate from the mine waste dumps and natural acidic run-on from scar areas is collected and purposely directed by Molycorp to groundwater within the new underground mine, the numerous fracture systems in the vicinity of the mine (which are well documented in the geological literature) may provide an avenue for the collected waste water to reach the Red River. Several statements from a recent hydrogeological report suggest this possibility. The past rate of dewatering the mine, 0.55 cubic feet per second (cfs), is less than 40% of the estimated amount of water available to recharge (1.45 cfs) (South Pass Resources, July 7, 1993, p. 8). Therefore, approximately 0.9 cfs is not collected by the mine. The report continues to state that fractures in the volcanics may provide an avenue for recharge to reach the Red River. Numerous geological reports mention that dominant structural features (fractures) in the mine area trend NNE to NE. In the most recent report by Molycorp (SPRI, April 21, 1995) on the hydrogeology of the mine area is the statement: "A common thread to all these geologic studies is that the mineralization at Questa was related to Tertiary magnetism and hydrothermal solutions focused along an east- to northeast-trending structural zone." Outcrops exposed along Highway 38 just east of the Questa Ranger Station display prominent, vertically-dipping fractures that strike N55E (toward the waste dumps in upper Capulin Canyon). Acidic seeps emerge into the Red River where this fracture zone intersects the river (Figures 3 and 4). Another geological report (Schilling, 1956) states that there is only one fracture system common throughout the Taos Range; it trends east to northeast and dips vertically to steeply north. In Sulphur Gulch (area containing the open pit) fracturing is especially well defined and strikes east-west. These fractures would therefore direct groundwater and seepage from the pit area west and southwest toward the concentration of acidic seeps along Red River near the mouth of Capulin Canyon.

Conversations with the Molycorp mine manager regarding mine schematics revealed that new underground workings progress below the elevation of the Red River. Most of the drainage in Sulphur Gulch (on-site precipitation and surface run-on) drains through the floor of the open pit, and makes its way into the old underground mine workings, and thence to a 700-foot vertical bore hole that conveys the water into the new underground mine workings. This water (along with inflow of surrounding groundwater as the former cone of depression in the water table rises) was filling the new mine workings during the period of this investigation (1992-1994). Pumping to dewater the mine began in 1995. Another source of water that is being introduced into the underground mine (and hence to groundwater) is derived from the ARD (in this case, the worst-quality water so far observed in the watershed) flowing from the base of the large waste dumps in upper Capulin Canyon and Goathill Gulch. Some of this ARD has been collected with seepage barriers by Molycorp since 1991, and is conveyed through a 1700' horizontal borehole beneath the ridge dividing Capulin and Goathill, and is then allowed to flow down Goathill Gulch and into the new underground mine workings via a large collapse depression known as the caved area (Figure 7). The collected ARD is discharged into the caved area at flow rates of approximately 70 gpm. Average total base flow of waters introduced into the new underground mine workings is estimated to be 100 gpm (70 gpm from the horizontal borehole and 30 gpm from the base flow drainage into the open pit in Sulphur Gulch) (Vail Engineering, July 9, 1993). Stormwater runoff is also purposely diverted into the caved area (via the Sulphur Gulch open pit as well as runoff from Goathill Gulch). Since run-off and collected leachate from mine waste dumps is purposely directed to groundwater in the mine, a release to groundwater exists due to the presence of contaminants in the leachate from the mine waste dumps (South Pass Resources, July 14, 1993, p. 11). The elevation of the water level in the mine workings is being maintained by pumping at approximately 7600 feet (150 feet below the elevation of Red River at Goathill Gulch) (NMED field notes, personal communication with D. Shoemaker (mine manager), Nov. 1994). However, the Red River is a gaining stream at this location. One survey (USGS, Oct.25, 1988) measured an increase in flow of 4 cubic feet per second between Columbine Creek (upstream from Goathill Gulch) and Bear Canyon (approx. 1 mile downstream from Goathill Gulch). This stretch of the Red River measures 2.8 miles and includes groundwater seeps along the northern streambed. Because these seeps have perennial flow, the water table is inferred to be the approximate elevation of the Red River which is 7,750 feet at Goathill Gulch.

The mine site has some overland flow that is not intercepted or diverted to the underground workings. New NPDES discharge locations have been included into the current NPDES permit and the construction of a rock drain at the toe of the mining waste piles adjacent to Hwy 38 purposely conveys run-off to the Red River (NMED, February 28, 1994).

The Fagerquist's Cottonwood Park is a small, 12 unit resort approximately 1/3 mile south of the Molycorp mine and 100 feet below the confluence of Columbine Creek and the Red River. The resort's well represents the nearest well supplying drinking water. With the facility on the south side of the Red River, the source for their groundwater supply is likely recharge from the Columbine Creek area. Although less likely, a portion of their water supply may come from groundwater which has drained from the north side of the Red River. Field reconnaissance has determined that no other private wells exist between the mine and Questa Ranger Station on the north side of the Red River (same side as the mine site).

The most recent and comprehensive discussions of the hydrology of the Molycorp mine site are found in consultant reports prepared for Molycorp (South Pass Resources, July 14, 1993, Jan.28, 1994, and April 13 and 21, 1995; Vail Engineering, July 9, 1993).

Hydrology of the Molycorp Tailings Impoundments

Numerous groundwater seeps and springs (approximately 25) have been identified along the Red River below the tailings ponds. An accretion rate of approximately 18 cfs to Red River has been described from the springs draining the area in Section 35 (Vail Engineering, September 24, 1993). Some of these have been used as an assessment of ambient groundwater quality whereas others have been hydrologically influenced by the tailings ponds. A recent hydrogeological report identified five seeps with elevated sulfate concentrations which included seepage attributable to the tailings (Vail Engineering, Sept.24, 1993). Two of these seeps/springs provide a portion of the water supply for the Red River Fish Hatchery (60% spring water, 40% Red River water). The lower reach of the Red River (from Cabresto Creek to mouth of Red River) has been measured having an average accretion rate (seepage of groundwater) of 31 to 33 cfs out of a total flow of 84 cfs at the mouth of Red River (Winograd, 1959, p.40).

Groundwater and surface water monitoring data presented to NMED by Molycorp in April, 1987 revealed contamination in wells downgradient from the tailings ponds. Analyses of monitoring wells, surface water discharge points and one private well was used to characterize leachate from the tailings ponds. One problem from the 1987 data is that there is no clear background well. The report, acquiring data from 1985 and 1986, used analytical results from numerous springs and two wells in the area as background conditions. These two wells, BLM Chiflo Campground Well and BLM Headquarters Well, are located three to four miles northwest of the tailings ponds and are screened in the deep basalt aquifer at depths of 415 feet and 546 feet, respectively. All springs used to characterize background conditions are located along the Red River where only basalt exists; the Santa Fe Group alluvium is not present (South Pass Resources, Sept.23, 1993). Subsurface hydrology is complex; characteristics of water from seeps located closely together can differ considerably. Use of analytical results from numerous springs, wells and seeps may not have accurately reflected background conditions, especially for the portion of the tailings ponds which overly the Santa Fe Group alluvium. Groundwater analyses submitted by Molycorp in September, 1993 used an off-gradient well to reflect background conditions. This well, labelled MW-CH, is screened in the middle to lower units of the Santa Fe Aquifer. Results from these analyses show elevated levels above background of iron, manganese and zinc in several monitoring wells and detected levels of chromium and lead in one monitoring well (South Pass Resources, Sept.23, 1993, Table C-1). Elevated concentrations of TDS and sulfate have always been present in samples from many of the Molycorp tailings area monitoring wells, with occasional elevated concentrations of Mo and Mn in some of the wells. Typical values (in mg/l) for contaminated groundwater at the tailings area are: TDS=1700, SO4=840, Mo=2.0, Mn=1.4 (Vail Engineering, September 24, 1993). The most recent data and discussion of the hydrogeology of the Molycorp tailings area are found in a report by South Pass Resources, April 13, 1995 (summarized in Appendix E).

2.3.1.2 MINING AREAS ON TRIBUTARIES

Most of the mining activity in the Red River watershed is concentrated in seven tributaries and in the middle reach of the mainstem. The tributaries with concentrations of mining activity are Bitter, Pioneer, Placer, Goose, Bear, Black Copper, and Cabresto Creeks. The most significant clusters of small mines and mineral impacts are in Bitter, Pioneer, and Placer Creeks (Figure 8). Most of the historic mining activity in the Red River watershed has been either underground or placer mining, with associated milling operations. Bitter Creek has at least sixteen abandoned mine sites that contribute NPS pollution by either runoff or seepage to the Red River. Only two mines, the Oro Fino, and the Memphis contribute ARD to Bitter Creek in regularly detectable amounts (NMED-SWQB, Jan., 1995). This volume of steady-state drainage is not significant in the overall picture of metal loading in the Red River. All of the mines along Bitter Creek contribute significant levels of NPS pollution in pulse events. Metals commonly found at elevated concentrations in both pulse and steady state drainage in these streams includes iron, aluminum, lead, copper, cadmium, and molybdenum. Pioneer Creek has at least 14 small mines that contribute significantly to metal loading in pulse events, but none of these produce significant volumes of steady-state drainage. At least 12 mines along Placer Creek contribute noticeably to pulse contaminant loading, but again the steady-state contribution is quite low.

Some of the mine sites along the tributaries of Bitter, Pioneer, and Placer Creeks had associated mill facilities during their operational periods. These mostly small mills crushed and processed ores and disposed of mill tailings along with the coarser run-of-mine wastes. Certain mill beneficiation processes used cyanide and mercury, but water samples have yet to detect these substances at significant concentrations in the vicinity of the old mills.

Bitter Creek is a major source of NPS concerns in this watershed and is effectively split into two distinct hydrologic units by three reservoirs located just above a large slump area (hydrothermal alteration scar) three miles above town (Figure 6C). SWQB staff observed Bitter Creek immediately after a summer rain event in August 1994. Turbidity values below the slump were in excess of 1000 NTU, in contrast to samples taken upstream of the reservoirs where turbidity was measured at less than 25 NTU. During this particular storm event, based on visual observations and turbidity measurements, the lower portion of Bitter Creek apparently is the greatest single source of sediment loading in the Red River watershed. In addition, Bitter Creek delivers the first regularly detectable infusion of acidic, metal-loaded water to the Red River through groundwater flowing within alluvium of the channel. Groundwater sampled from two private wells on lower Bitter Creek (Figure 6C) in 1993 showed indications of ARD influence; the pH was 4.6 and 4.9, and iron, aluminum, and other metals were elevated. This subchannel groundwater flow may originate as surface water above the unstable slump area and infiltrate into the aggregation of unstable material that forms the slump to emerge intermittently in Bitter Creek under normal flow conditions. Where Bitter Creek discharges into the Red River can be seen the first occurrence of white mineral deposition on the substrate of the river. These deposits, mainly aluminum hydroxide, indicate ARD and the associated acidic pH changes, but the effects here are minimal in extent and duration compared to the major seep areas below Molycorp mine at Capulin Canyon.

2.3.2 HYDROTHERMAL ALTERATION SCARS

Within the Red River watershed there are approximately twenty prominent erosional scars that affect the river negatively during pulse events (Figure 4). The most comprehensive discussion of geological controls on alteration scar formation in the watershed is found in a paper by Meyers and Leonardson (1990), from which the following excerpts are taken:

> "Alteration scars are landforms characterized by steep slopes, a lack of soil, iron oxide staining and clay formation, rapid erosion and common slumping and landsliding. Scars are the most visible geologic features of the Questa-Red River region and are significant in that they represent source areas for mudflows that pose a substantial geologic hazard and have significantly altered the topographic form of the Red River drainage...During times of high precipitation, waters from these scars turn the Red River orange, giving the river its name...Recent geologic mapping by the authors has led to the re-interpretation of these scars as resulting from landsliding, and other erosional processes that are enhanced in regions where the rock has been weakened by faulting and supergene (secondary) weathering of pyrite...Low-angle fault zones are pervasive throughout the Questa-Red River region and served as conduits for intrusions, molybdenum mineralization, pyritization, and as zones of weakness for later landsliding and scar formation...High pyrite zones (>3% pyrite) were favored sites for later landslide activity and scar development...a dominance of mass transport processes inhibit

> soil development...Secondary earth materials in the alteration scars include colluvium and ferricrete...Ferricrete is an iron oxide and silica-cemented rock that forms in regions of seepage from shallow-source waters that recharge from higher portions of the scar...Highly permeable colluvial deposits are commonly cemented during this process and form striking ferricrete breccias...A number of geologic factors control development of alteration scars...In order of decreasing significance, the major controls are slope angle, tectonic fracturing, pyrite content, and vegetative cover. A slope angle in excess of 25 degrees is a primary requirement for generation of all alteration scars in the region. Slope angles less than 20 degrees do not contain the driving force required for the initiation of mass-wasting processes...Pyrite contents of 3-5% are common in scar areas, whereas pyrite contents near 1% are typical throughout most of the region. Pyrite weathers in the near-surface environment to form iron oxides and sulfates. Acidic water generated from oxidation of pyrite reacts with feldspar minerals in the rock to form clay minerals, which have very low shear strength when saturated with water...Scars are believed to be initially exposed by landsliding in regions that are oversteepened by headward erosion of drainages...Erosion of scar interiors occurs at a very rapid rate, as drill roads in scars that are 20-25 years old are locally dissected by as much as 10-15 m...The scars pose a hazard to the region as a significant number of roads, buildings, and campsites are located on debris aprons deposited by mudflows that originated from the scars...In 1982, mudflows from the Hansen scar area resulted in a fatality to a motorist...The debris aprons cause stagnation of flow in the Red River drainage and the formation of upstream meadows."

Some of the scars show signs of mineral exploration roads and mines that obviously predated the present accelerated erosional episodes. Most of the erosional scars are located on south-facing slopes where vegetative colonization is tenuous. Any sort of disturbance that provides a nick point for erosional headcuts to begin can result in the loss of entire mountainsides. Where this process is advanced, the exposed fractured sulfide rock comes in contact with precipitation and oxygen, and acid drainage is the result.

The increase in metal loading of the Red River in a downstream direction is at least partially attributable to the acid drainage from scar areas (Smolka and Tague, 1987 and 1989; Vail Engineering, July 9, 1993), although, as mentioned above, many of these areas have been modified by a number of anthropogenic activities. While some of this drainage reaches the Red River by overland flow (e.g. Hansen Creek and Haut-n-Taut Creek), much infiltrates the colluvium and river channel alluvium and discharges to the Red River through seeps/springs. Many of these seeps have perennial flow, even during dry seasons. Therefore, an undetermined portion of the seep is likely attributable to groundwater which recharges the river. Similar problems exist elsewhere in other mining districts that also contain scar areas. Since the advent of the Summitville Mine disaster in Colorado in 1993, much research has been conducted in that area. Sources of acidity and heavy metals in the Alamosa River Basin (from both mining and seeps related to natural scar areas) have been extensively studied (Kirkham, et. al., 1995). In some watersheds it was found that most degraded water resulted from natural processes, and in others the relative contribution of mining was calculated from estimated flow rates and loading of dissolved metals.

2.3.3 LEAKING UNDERGROUND STORAGE TANKS

In the Red River watershed there are three known sites where underground storage tanks have leaked petroleum products, all within the Town of Red River. None are yet known from the Village of Questa. The three sites in Red River are in various stages of investigation and remediation under the oversight and regulatory authority of the NMED Underground Storage Tank Bureau (USTB). A release from at least one of the sites was documented as directly contaminating the Red River with hydrocarbons. There is also the ever-present threat to water resources from petroleum products spilled in accidents, dumped illegally, or disposed carelessly (i.e., individuals changing motor oil near streams or storm-drains). The known leaking USTs are described below:

Chevron Red River: Southeast corner of Main Street and Jacks & Sixes Street in Red River. This facility is closed and is now occupied by High Country Jeep Rental. Contamination was discovered during removal of three USTs in August 1991. The site became a State Lead Site in the USTB in May 1992 after contaminated groundwater was discovered entering a storm sewer drain that emptied to the Red River 350 feet south of the site. Groundwater at the site is very shallow, fluctuating seasonally to within two feet of the surface. A hydrogeological investigation was completed in August 1992 with the installation of twelve monitoring wells. An air sparging remediation system was installed by July 1993, with an estimate that cleanup would take two years. Quarterly sampling is done to monitor the systems effectiveness and rate of contaminant reduction, which has been satisfactory.

Old Diamond Shamrock Station: This was formerly a Chevron Station and is located on the south side of Highway 38 in the center of Red River. In September 1991 four tanks (3,000 gallons each) were permanently closed. The tanks were almost completely under water (shallow groundwater), and contamination of both soil and groundwater was documented by inspectors. The water table at the site is as shallow as three feet, and the Red River is located 150 feet to the south. The responsible party (Colomex Oil and Gas Co.) was very delinquent in responding to repeated requests and warnings from the USTB to begin the required site investigation and remediation process. In January, 1995 a consultant had been retained to initiate a hydrogeologic investigation (personal communication, Chris Holmes, USTB, January, 1995).

Red River Ski Area: Located at the Red River Ski area between the maintenance shop and Pioneer Creek. The site is still active but two USTs were removed in May 1993. The tanks were within 50 feet of Pioneer Creek. Contaminated soil was detected by the USTB inspector at the site (to 1300 ppm at a depth of 16 feet). A site summary by the USTB in August 1993 includes these remarks: "considerable soil contamination, Pioneer Creek is threatened, contaminated soil placed onsite, this site has languished...". Several joint site inspections were made during 1994 by staff of SWQB and USTB to check for signs of hydrocarbon pollution in Pioneer Creek and to motivate the operator to comply with the required site investigation and remediation process. On January 6, 1995 the operator submitted the required On-site Investigation Report. The report described the six soil borings and five monitoring wells installed and sampled. The contamination is diesel fuel and is present only in the immediate vicinity of the former USTs. Plans for remediation are underway.

2.3.4 SEPTIC TANKS AND SEWAGE LAGOONS

The upper Red River valley (above the Town of Red River) has become densely developed with subdivisions having hundreds of homes on small lots (Figure 2). A total of at least 410 houses are reported to exist in the upper valley as of 1995 (personal communication, Bob Perry, Director of Public Works, Town of Red River, 1995). Many of the lots are as small as 1/4 acre, and all have individual liquid waste systems (septic tank leach fields or holding tanks). There is no community waste treatment system or water supply system in the upper valley. Because these leach fields are in close proximity to the river (some homes are within twenty five feet of the river) in an area of very shallow groundwater and permeable alluvial soils, there is a concern that effluent from the leach fields is contaminating the shallow groundwater and seeping into the river.

The Village of Questa discharges up to 60,000 gallons per day of domestic sewage to a series of four lagoons (a fifth is currently under construction) located 1.5 miles southwest of Questa and approximately 300 feet from the Red River. This discharge is permitted and monitored under a NMED Ground Water Discharge Plan (DP-191), which was originally approved in 1983. The location of the lagoons is shown in Figures 2 and 3. These lagoons are unlined and are designed to function as rapid infiltration basins. (Questa is in the process of installing two lined lagoons for primary aeration and settling, which will precede discharge to the infiltration lagoons). The Red River is a gaining stream in this area (see Section 2.1.1) and groundwater flow is from the lagoons toward the river. Some groundwater contamination is expected to occur in a limited area, and is monitored by a set of four monitoring wells located between the lagoons and the river. Property owners in the area have agreed not to drill any wells nearby. The ultimate discharge of the sewage effluent is to the Red River, where due to dilution by river water and by groundwater flowing through the highly transmissive alluvial aquifer, contaminant levels are expected to be well below surface water standards. Concentrations of the expected contaminants (nitrate, TKN) have in fact been below state standards in the monitoring wells and in the river (DP-191 file, NMED Ground Water Section).

III. INVESTIGATION

3.1 METHODS AND DATA COLLECTION

3.1.1 General Approach - Research Design

Water quality data from samples collected by NMED are summarized in Tables 1 and 2, with locations of samples shown in Figure 6. All field procedures and analytical work were performed in accordance with the SOPs for the NMED Groundwater Quality Bureau and Surface Water Quality Bureau. Field screening was used to select sample points (measurement of field parameters such as pH, conductivity, temperature, DO, turbidity). All analytical work was done by the NM Scientific Laboratory Division (SLD) in Albuquerque in accordance with the QAPP for this project, with the exception of data generated by the NMED Superfund Oversight Section, which used EPA Contract Laboratories (that data is tabulated in Appendix A). Sampling was designed for the following locations and purposes:

1. Twelve monitoring wells were drilled by Molycorp along the Red River between the Molycorp mill and the Questa Ranger Station to determine groundwater quality, evaluate aquifer characteristics, and to aid in attribution of the sources of numerous acidic seeps that are impacting the river. Appendix C contains the rationale for well locations, screen placements, and completion data for these wells. All drilling and sampling activity was closely coordinated between NMED programs, Molycorp, and South Pass Resources Inc. (SPRI - consultants to Molycorp). Wells were sampled in November, 1994 for metals (total and dissolved) and anions/cations in accordance with the QAPP and with protocol established by the NMED Ground Water Section. Sampling frequency will be semi-annually for the first year (in order to evaluate seasonal hydrologic fluctuations), and annually after the first year. Data generated by this project will be evaluated by comparing the analytical results to the numerical water quality

standards for groundwater promulgated by the NM Water Quality Control Commission (WQCC).

2. Groundwater was sampled by Molycorp within the underground mine workings (see Appendix D, Table D4), to characterize the water that is currently flooding the mine, as well as to characterize background groundwater where it enters the upgradient side of the mined area as seeps. Samples were analyzed for metals (total and dissolved) and anions/cations, on a one-time basis. Molycorp has been recording water levels and sampling water in the mine on a monthly basis.

3. Potential impacts of the old Molycorp "landfill" in Spring Gulch were evaluated. Two monitoring wells (MMW-14 and 16) were installed by Molycorp in the vicinity of the confluence of Spring Gulch and Sulfur Gulch in 1994. Reports from EPA inspections were evaluated, and the site was inspected again in 1994 by SWQB staff.

4. Existing wells located upgradient of Molycorp (Red River Wastewater Treatment Plant, Molycorp mill production wells) were sampled to better determine "background". Samples were analyzed for metals (dissolved) and anions/cations, according to the protocol established by the NMED Groundwater Section.

5. Approximately ten selected acid seeps along the Red River were monitored for changes through time. Seeps were observed, measured for field parameters, and sampled for metals (total and dissolved) and anions/cations. The most significant source area for acid seeps (Capulin Canyon) was sampled on five different occasions to check for seasonal variations and to provide sufficient data for statistical analysis.

6. Samples were collected from the Molycorp mine dump leachate from seepage collection systems in head of Capulin Canyon and Goathill Gulch. Water chemistry was compared to that of the acid seeps along the Red River. Samples were analyzed for metals (total and dissolved) and anions/cations.

7. River water was sampled to evaluate possible contamination from septic tanks in developed areas along headwaters of the Red River upstream of the Town of Red River. Samples were collected one time only, during the summer season (most of these houses are summer homes), and analyzed for NO3, TKN, and anions/cations.

8. The existing monitoring wells (14) and springs in the Molycorp tailings area were sampled in order to update the existing data base of water chemistry for characterizing groundwater contamination from tailings and the possible impact to the Red River. Included are the two springs used for water supply by the Red River Fish Hatchery. Monitor wells were sampled in August, 1993 and November, 1994.

Along with the sampling program listed above, the following pertinent and accessory tasks were undertaken as part of this project:

1. Acquire and study well/borehole logs and well construction details for wells sampled in order to meaningfully compare analytical results.

2. Conduct further sampling and observations on the scar areas in the Red River watershed in order to better understand the relative contribution of acidic, metal-laden waters from the scar areas and from recent mining activity.

3. Evaluate aerial photography for structural clues in aiding placement of monitoring wells, and possible clues concerning fracture systems that could influence groundwater movement in the mine area.

4. Evaluate the possibility of conducting dye tracing experiments to confirm hydrologic connections between the seeps along Red River and certain areas on the Molycorp property.

5. Investigate three sites in the Town of Red River where underground storage tanks (USTs) are reported to have leaked. Coordinate activities with NMED UST Bureau (the lead agency for enforcement/remediation of USTs). This project will evaluate the status and effectiveness of efforts by the UST Bureau and will assess any groundwater contamination impacting the Red River from USTs.

6. Continue to monitor performance of the Oro Fino Mine demonstration project (anoxic alkaline drain) on Bitter Creek, a tributary of the Red River, that was installed in September, 1993. Performance is evaluated by measuring field parameters and sampling discharge for metals (total and dissolved) and anions/cations, on a semi-annual basis.

7. Conduct X-ray Fluorescence (XRF) surveys of mine wastes at Molycorp (tailings and mine dumps) and possibly other mining sites in the watershed to better quantify metals concentrations available for release to surface water and groundwater. The XRF work at Molycorp will be done in cooperation with a NMED Superfund investigation.

8. Conduct an inventory of septic tanks and other onsite waste disposal systems in the heavily developed areas upstream of the Town of Red River. This information can be used to evaluate the likelihood of groundwater contamination from septic tanks in the headwaters of the Red River. It can be used to plan sampling methods and locations.

9. Complete an inventory of all abandoned mine sites in the tributaries of the Red River (Placer Creek, Pioneer Creek, Bitter Creek, Cabresto Creek, Goose Creek, and Black Copper Canyon). Prioritize sites according to their threat to groundwater and the Red River.

3.1.2 Molycorp Mine Site

A release of contaminants to the Red River from the mining site results primarily from ARD-impacted groundwater seeps which are derived in-part from infiltration through the waste rock piles, open pit, and underground workings. While much of the run-off from the waste rock piles is directed to groundwater via the mine workings, a portion of the runoff may drain to the Red River. Some of this runoff is collected and discharged (during extreme runoff events only) to the Red River via Molycorp's recently renewed NPDES permit. Other nonpoint source discharge occurs where rock drains have been constructed at the toe of waste rock piles in Sulphur Gulch to convey water to the Red River (NMED, Feb.28, 1994, p. 29). Most of the overland flow not discharged under the NPDES permit is likely to infiltrate the alluvium of tributaries and the river channels prior to reaching the Red River. Therefore, seeps/springs located downstream from the mining site were sampled and evaluated.

Evaluation of the impact of the Molycorp mining operation on the Red River must distinguish effects which occur naturally. Background and downgradient groundwater samples were used to determine any observed release of contaminants. With variations in lithologies (including the presence of alteration scars that surround and underlay much of the Molycorp site), geologic structures, and mining operations over the entire mine site, background conditions are not considered to be homogeneous. Therefore, several sampling locations were used to evaluate background groundwater chemistry. These locations (listed below) have been selected to represent groundwater which flows through either the fractured bedrock aquifer, the alluvium of the Red River channel, or alluvium in the side channels (tributary drainages) which is impacted by natural scar drainage. Separation of groundwater flow into these three systems is useful in understanding general hydrogeology near the mine site and assists in defining sources for the seeps near the Red River. It does not, however, necessarily preclude communication among systems.

Potential background groundwater samples were collected from seven separate sources to evaluate groundwater contamination from the mine: the water which is currently filling the new underground workings; water accumulating in higher-level mine workings; a groundwater sample from one of the two production wells at the mill site; a groundwater sample from the Red River Waste Water Treatment Plant; samples from wells at Elephant Rock and Fawn Lake Campgrounds; and a seep near the mouth of Hansen Creek (fig. 6C). The water which is currently filling the mine (new workings) is groundwater which receives surface run-off and collected leachate (ARD) from the mine waste dumps. While this groundwater is presumably impacted (i.e. geochemically altered) by surface drainage, it is of better quality than seepage at the river and may be useful as an approximation of background conditions for comparison to the seeps along the Red River. With few alternative sampling locations, use of the groundwater from the deep mine workings to represent background conditions was deemed appropriate.

Downgradient groundwater samples were collected from twelve of the seventeen seeps (Figure 6, Table 1) which have been identified along the Red River from Molycorp to Questa Ranger Station (Vail Engineering, July 9, 1993). Selection of specific seeps to be sampled was based upon field readings of electrical conductivity and pH during preliminary field reconnaissance. One of these seep areas is located at the mouth of Capulin Canyon and extends approximately a quarter-mile below Capulin Canyon (Figures 3 and 7). An opportunity for collecting a sample of ARD-influenced groundwater near the Capulin seeps was serendipitously provided by highway construction during September, 1993. An excavation on the north side of Rt. 38, approximately 700 feet south of Capulin Canyon, revealed groundwater at a depth of only six feet with a pH of 3.9. Other, equally poor quality seep water was also found filling a segment of old (abandoned) river channel approximately 500 feet downstream of the mouth of Capulin Canyon. All of the above sample locations are part of a single source consisting of a linear seep front along the north bank of the Red River extending from the mouth of Capulin Canyon downstream for hundreds of yards. Samples of groundwater considered to be down-gradient of Molycorp mine wastes were also collected at other seeps, notably the Portal Spring and Cabin Springs areas (Figure 7).

Sampling included water samples from both the seeps and Red River. Surface water samples were collected above the Molycorp property boundary, below Sulphur Gulch, above, within and below Columbine Creek (a major tributary) and above and below each of the two reaches where seeps are numerous. Samples of surface water and seepage were analyzed for both metals and general chemistry.

To evaluate possible impacts from the former Molycorp waste disposal (landfill) site in Spring Gulch, reports from EPA Site Inspections (1983 and 1985) were evaluated, and the site location was inspected. Two groundwater monitoring wells were installed in Sulphur Gulch below the mouth of Spring Gulch in the 1994 drilling season, but these wells have so far been dry.

Determining attribution of contaminants to the Molycorp Mine requires the characterization of leachate emanating from the waste-rock and comparison to water chemistry of the acid seeps. Water chemistry was evaluated at water sampling locations to determine whether a chemical similarity exists between the leachate from the mine waste piles and the downgradient seeps. Leachate samples were collected from the toe of the waste-rock piles at the head of Capulin Canyon and Goathill Gulch (Figure 7). Leachate samples were also collected from hydrothermal scar areas (Figures 3 and 4). Molycorp consultants who are expert in ARD, along with Unocal research staff, are continuing to research methods of fingerprinting waters from various sources at the mine site, including environmental isotopes (Steffen, Robertson and Kirsten, April 21, 1995).

Dilution of groundwater from seeps by river water flowing through the alluvium was expected. Sampling sometimes involved the collection of groundwater from small pits dug into the river alluvium immediately below a seep. Sampling was located closer to the mouths of the side canyons so as to minimize the dilution by river water within the channel alluvium. To minimize the number of sampling pits, selection of pit locations was directed toward those seeps containing higher concentrations as determined during reconnaissance sampling. Samples were analyzed for general chemistry and metals.

During the period July-September, 1994, Molycorp drilled twelve new monitoring wells in the mine area, at various locations along the Red River canyon. Locations of these wells are shown on Figures 6B and 7, and the rationale for their siting, along with completion information is given in Appendix C. These are the first monitoring wells to be drilled in the vicinity of the mine and the waste dumps. They were sampled initially in early November, 1994. A discussion of the results of sampling and well pumping tests is given in Appendices B and D. In addition to these twelve new wells in the mine area, two new groundwater extraction wells (for use in remediation) were also drilled in the tailings area during the 1994 drilling season. Consultants responsible for planning and monitoring the drilling program were with South Pass Resources. Major reports from South Pass Resources evaluating the results were submitted to NMED in April, 1995, along with recommendations for the next phase of investigations. In addition, other Molycorp consultants (Vail Engineering) have been conducting semi-annual river surveys of the middle reach of Red River to sample and measure pH and conductivity at dozens of stations (river water and seeps). The consulting firm of Steffen, Robertson, and Kirsten has conducted an initial geochemical assessment of the mine site to evaluate ARD conditions there (Stephen, Robertson and Kirsten, April 13, 1995). A summary of their findings is given in Appendix F.

3.1.3 Molycorp Tailings Site

Because the Molycorp mine site apparently has a greater relative impact on Red River water quality than does the tailing impoundment area (where most of the seepage is intercepted and directed through an NPDES-permitted outfall), less emphasis was placed on investigation of the tailings area in this project. This rationale is further justified by the fact that a great deal of work had already been done in the tailings area in past years by NMED Groundwater Section and by Molycorp consultants. For instance, although the mine area had no monitoring wells prior to 1994, the tailings area contained fourteen existing monitoring wells when this project was initiated. Much analytical data from the existing monitoring wells and from private wells and springs was already available. However, some existing wells were sampled in conjunction with ongoing investigations of the tailing area by both the NMED Groundwater and Superfund Oversight Sections during this project, and several newly installed monitoring and extraction wells were also sampled. The most comprehensive discussions of seepage from the tailings dams are contained in reports by Molycorp consultants (Vail Engineering, September 24, 1993 and August 24, 1989; South Pass Resources, Sept.23, 1993 and April 13, 1995).

The purpose of groundwater sampling in this area was to document or confirm a release to the aquifer underlying the tailings ponds and determine the level of contamination and the relative contribution to the Red River. Sampling locations consist of those monitoring wells recently sampled by both Molycorp and NMED-Groundwater Section which demonstrated elevated levels of TDS and sulfate. Prior analyses of monitoring wells 1-4 showed detectable levels of lead, zinc and copper in well #3 and zinc in the other wells (NMED, Feb.28, 1994). All four of these monitoring wells were sampled. One background sample was collected from a monitoring well, labelled MW-CH, located east of Dam 1 tailings pond, and from major springs located in the Rio Grande Gorge (Figure 6A).

3.1.4 Other Nonpoint Sources

Septic Tanks

As mentioned earlier, the upper Red River valley (above the town of Red River) has become densely developed with subdivisions having hundreds of homes on small lots. Many of the lots are as small as 1/4 acre, and all have individual liquid waste systems (septic tank leach fields or holding tanks). During site inspections in 1994 an attempt was made to count the number of houses in this area. In the area between Fourth of July Canyon and Foster Park Canyon (an area of 1.5 miles by .25 miles) approximately 125 houses were counted. This area includes the Valley of the Pines Subdivision (the lowest subdivision in the upper valley), and many of the houses are located very near the banks of the river. Others are built on very steep slopes that appear to have thin soils overlying bedrock. The subdivisions in the upper valley area above Fourth of July Canyon contain approximately 200 houses (difficult to count because many are in forest). An initial effort to quantify the septic tank situation was made by contacting the NMED Field Office staff in Taos, NM for information about liquid waste permits, which are required for construction of any household waste disposal system. The Environmentalist in charge of the Red River area (Bill King) indicated that such information would be meaningless because some builders in that area apparently do not apply for the permit and install their septic tanks illegally. He had only received two requests for liquid waste permits in the last six months, and believed that many more houses than that had been built in that period. Enforcement is a problem. Other NMED staff from SWQB were told of concerns by a local resident about illegal installations by a local plumbing contractor in the area who was installing holding tanks (that should be pumped out when full) with holes punched in the bottoms. Strategies for documenting pollution in groundwater and the river include sampling the river near observed algal blooms, and sampling private wells for analyses of nitrate and TKN. As a field screening technique to identify possibly contaminated wells, approximate nitrate concentrations can be determined in the field by using one of the Department's Hach Kits, which use a colorimetric technique to quantify nitrate (10 mg/l is the NM groundwater standard). Confirmatory samples would then be submitted for laboratory analysis.

During 1995 others expressed additional concern over potential problems in the upper valley, and began coordinating activities in this regard. Bill King (NMED, Taos Field Office) reported receiving increasing numbers of complaints from upper valley residents about failing septic systems. (Efforts to address septic systems are handled through NMED's Liquid Waste Program). Bob Perry (Director of Public Works for Town of Red River) assumed a leadership role in the recently created Red River Watershed Association, and began to focus on the water quality impacts in the upper valley. From a coordination meeting between these parties in April, 1995, it was determined that there are approximately 450 houses in the upper valley now, with a capacity for about 1000 more in the future. Only 203 houses have been issued Liquid Waste Disposal Permits from NMED since 1973, implying that over 200 have illegal systems. It is assumed that there are at least 400 private water supply wells in the area. In order to curtail the installation of more illegal systems and to alleviate existing (probable) water quality impacts to the Red River from the upper valley, the Town of Red River would like to extend its sewer and water service to the upper valley. The existing WWTP can handle the increased flow, and costs are estimated at approximately ten million dollars. The town is applying for assistance in funding this project, and hopes for completion in about five years. In order to further document the need for this project, several activities will be conducted in the upper valley during the summer months of 1996 in joint efforts between the Town of Red River, the NMED Taos Field Office, and NMED-SWQB. A Water Fair will be held, during which residents can bring samples of their well water for testing and analyses (nitrate screening being used to indicate possible contamination with septic system wastes). To follow up on wells that may be contaminated, inspections and possibly dye traces will be conducted. Both banks of the river will be walked through developed portions of the upper valley to look for evidence of illegal direct discharges to the river and for signs of failing septic systems in proximity to the river.

Leaking Underground Storage Tanks

Since the NMED Underground Storage Tank Bureau (USTB) has regulatory authority over investigation and remediation of sites contaminated by leaking USTs, the role of this project in regard to UST sites has been to consult with and maintain close communication with the appropriate technical staff in the USTB about progress at the three known sites in the Red River watershed. Their files were copied and incorporated into the records for this project, and site visits were coordinated with USTB staff for all three sites in Red River. Quarterly monitoring reports, data, and consultants reports are provided to this project as they are received by USTB staff. Frequent inspections have been made for evidence of hydrocarbon release at the Chevron Red River site, where past discharges to the river through a storm sewer have been observed.

Questa Sewage Lagoons

The Questa sewage lagoons fall under the regulatory authority of the NMED Ground Water Section, which reviews the required groundwater monitoring at the facility through a Ground Water Discharge Plan (DP-191). These analytical results, which have not revealed contamination above State standards, are on file with NMED-GWS. This project reviewed the DP-191 file and consulted with Ground Water Section staff, but did not see a need to conduct any further sampling or field work at this site.

Scar Areas

The approximately twenty alteration scars in the watershed are a significant source of NPS pollution due to their extreme sediment yields in pulse events and, more importantly to this project, their steady-state ARD. It is therefore important to understand their geochemical nature in order to distinguish their naturally occurring "background" effects on Red River from the impacts of Molycorp and other mining sites. Much of the Molycorp mine site is surrounded by large scar areas in the upper parts of Goathill Gulch and Sulphur Gulch. The waste rock dumps in these drainages overlay scar material in places. Some scars that are distant from Molycorp (Bitter Creek, Hansen Creek, Haut-N-Taut Creek) have discharges of natural ARD, although some evidence of exploration roads and mining within these areas raises the question of how natural the erosion rates and consequent ARD generation are (Morain, 1996). In order to facilitate a better understanding of the role of alteration scars in Red River water quality, numerous scars were observed (primarily upstream from Molycorp) under conditions of base flow and pulse events. Seeps issuing from scars were documented and sampled, as well as surface runoff in tributary channels and Red River above and below their confluences. Preliminary laboratory leaching tests were conducted, as were a few XRF evaluations, of scar materials. Aerial photos were obtained and studied for clues in scar development and growth, and evidence of roads and mining activity within scars was documented. In a few locations on Bitter Creek it was possible to sample groundwater from private wells that are believed to be impacted by scar-derived ARD. Analytical results of groundwater were evaluated by various graphical and comparative methods along with sample results from Red River seeps and mine waste leachate. Further research into scar areas and BMP treatments will be forthcoming under a SWQB project directed at the slump (debris flow) problem in Bitter Creek in an EPA Section 319(h) FY95 Grant (94-B).

Old Mining Areas on Tributaries to the Red River

In order to evaluate the potential for nonpoint source impacts to the Red River from seepage of contaminated groundwater from mining sites in the old mining districts encompassing tributaries, extensive field reconnaissance was conducted in Placer, Pioneer, Goose, Cabresto, and Bitter Creeks, and Fourth of July and Black Copper Canyons (Figures 2 and 8). In addition, information was obtained from the following sources:

> Screening Site Inspection for the Red River Mining District, August 31, 1989, by Dale Doremus, NMEID Superfund Section.
>
> Geology and Ore Deposits of Eagle Nest Area, NM, 1972, by K.F. Clark and C.B. Read, NMBMMR Bulletin 94.
>
> USFS, Carson National Forest, n.d., brochure on the Mining history of Pioneer Canyon.
>
> USFS, Carson National Forest, Questa Ranger District, report and files from mine surveys conducted in 1990 and 1991 on Pioneer Canyon, Placer Creek, and Bitter Creek.

Results and further discussion of scar areas are given in Section 3.2.3.

3.2 RESULTS AND DISCUSSION

A summary of the analytical data for water samples collected by NMED-SWQB during this project is contained in Tables 1 and 2, with sample locations shown in Figures 6A,B,C. Data from samples collected by NMED Superfund Section in the 1994 investigation of Molycorp Mine are given in Appendix A. Other environmental data collected by Molycorp and their consultants are included in Appendices B through F. The analytical data reports from the various laboratories used by NMED-SWQB, NMED Superfund, Molycorp, and others are not included in this report; summations of the data are given in the appropriate tables. The data report sheets are on file with the respective sources.

3.2.1 Molycorp Tailings Area

As discussed in Section 3.1.3, the tailings area hydrogeology has been studied and characterized in numerous investigations by NMED and Molycorp consultants since the mid-1980's. The most current understanding of the hydrogeology and water quality of the area is presented in reports submitted to NMED by Molycorp (SPRI, April 21, 1995 [summarized in Appendix E of this report] and September 23, 1993). Portions of the discussion that follows are based on information contained in these reports. The most current analytical data for groundwater samples collected by NMED from wells in the tailings area are found in Tables 1 and 2, and in Appendix A.

Seepage from the tailings has contaminated the underlying shallow alluvial aquifer with elevated concentrations of sulfate and TDS, and in several monitoring wells with elevated concentrations of Mn and Mo. As an initial groundwater remediation (containment) effort, Molycorp has constructed seepage collection barriers between the toe of the dams and Red River. Collected seepage water is discharged to Red River via NPDES-permitted outfall #002.

In 1994 five new monitoring/extraction wells were installed in the tailings area by Molycorp, bringing the total number of monitoring wells in that area to fifteen. Water from wells located east of Dam #4 and south and east of Dam #1 are characterized by a high-TDS, calcium sulfate water that derives from tailings seepage.

The major hydrogeologic units in the tailings area are the Santa Fe Group (an alluvial sequence of aquifers and aquitards) and the underlying volcanic sequence consisting of a basalt unit that extends beneath both tailings ponds and a sequence of tuffs and lava flows in fault contact with the basalt and the Santa Fe Group along the west side of Dam #4 (SPRI, April 31, 1995). Groundwater flow paths are influenced by northeast-trending high-angle fault lines. There are multiple perched groundwater zones in the Santa Fe Group. The main perched zone is south of Dam #4 and may extend to the Red River.

Piezometric surfaces are complex composites involving unconfined and semi-confined conditions in the various units. The shallow private wells that are contaminated by leachate are probably screened in the main perched zone, whereas deeper wells screened in the basalt unit or lower aquifer unit of the Santa Fe Group contain water that meets drinking water standards (except for wells MW-1 and EW-1). Groundwater flow directions in the basalt aquifer range from S20W to S75W; hydraulic gradients range from 0.1 ft/ft to as low as 0.003 ft/ft. Flow rate estimates were calculated by

SPRI from a mixing equation for the volcanic aquifer at Dam #4 at 5.9 cfs. This suggests a high degree of dilution for any leachate from the tailings that reaches the water table (and the river), and appears to be supported by sulfate and TDS values of samples from MW-11, Red River, and springs down-gradient of Dam #4. Mixing equations and sample data both indicate that there is sufficient dilution from both the high groundwater flow rates in the basalt aquifer and from the Red River to dilute inflow from the perched zones to below State standards for both groundwater and surface water. The section of river that may be receiving tailings seepage is 1.8 miles in length (between the #002 outfall and the Fish Hatchery). This portion of the Red River is well-documented to be a gaining stream. The various studies that have been done in the area generally conclude that the net gain between Questa and the confluence with the Rio Grande is approximately 30 cfs. Vail (1993) provides the most recent estimates for groundwater accretion and the contribution of sulfate concentrations from each tributary source. Accretion estimates for the alluvial section of river between the highway bridge at Questa and the Questa Springs complex indicates sulfate concentrations can be expected to increase from an average value of 119 mg/l at the bridge to 131 mg/l below the springs complex. This calculation considers dilution of seepage waters having elevated sulfate concentrations in the range of 800 to 1000 mg/l. Samples of river water below the spring had a sulfate concentration of 138 mg/l. Similar results derived for the portion of the river in the upper gorge (above the Fish Hatchery). For more detail on these calculations and sampling data see Appendix E. Analytical data from samples collected by NMED-SWQB from springs flowing from the basalt aquifer at locations in the lower Red River Gorge and the Rio Grande Gorge (Figure 6C, Table 1) further support the general conclusion that seepage from the tailings area currently is not significantly impacting the Red River, and the seepage is not hydraulically connected to the Rio Grande. Similarly, the two spring complexes being used as a water supply by the Fish Hatchery, although seemingly in a vulnerable location near the tailings dams, are to date not contaminated above standards by leachate (Table 1, Figure 6C). In a seepage analysis of the tailings ponds Vail estimated that the Hatchery's warm water supply may be composed of approximately 43% seepage water from the tailings area (Vail Engineering, September 24, 1993). Sulfate concentrations in tailings seepage was given as 120 mg/l, and that from the spring discharge (a mixture of tailings seepage and clean groundwater) as 63 mg/l. Thus there is some contamination by tailings seepage in the Hatchery warm water spring, but due to dilution it does not result in an exceedance of groundwater standards.

3.2.2 Molycorp Mine and the Hydrothermal Alteration Scar Areas

The hydrogeology of the Molycorp Mine area has been previously discussed in Section 2.3.1.1 and is further discussed in reports by Molycorp consultants (South Pass Resources, Inc., Vail ngineering, and Steffen, Robertsen, and Kirsten, Inc.), portions of which are included as excerpts in Appendices B through F. Figures 4 and 7 show maps of the area, and analytical data relevant to this discussion are in Tables 1 and 2, and in Appendix A.

The middle reach of the Red River from Questa to the Town of Red River, and containing Molycorp Mine and most of the major scar areas, became the primary focus of this project because it is here that the most significant water quality degradation to Red River occurs. A number of river surveys by NMED and Molycorp have documented significant declines in Red River water quality progressing downstream from the town of Red River to Questa (Smolka and Tague, 1987 and 1989; Vail, July 9, 1993; and unpublished data). The negative but temporal impacts of stormwater runoff are likewise well-documented, and have been previously discussed. Management of stormwater runoff by Molycorp has apparently been effective in eliminating surface discharges from the mine site to Red River (based on NPDES reporting and on field observations during storm events). Of primary interest in this project is the role of steady-state contribution of ARD to Red River in the form of acid seeps and perennial drainage that originates from Molycorp sources as well as from naturally occurring hydrothermal alteration scars in the watershed. Distinguishing the relative contribution of these two sources is thus a critical aspect of this and other regulatory efforts focused on Molycorp. The commonly accepted approach of sampling groundwater at locations upgradient of the source(s) of contamination is not so easily applied at Molycorp Mine because of the presence of potential natural sources of ARD (scar areas) located upgradient of, and beneath, the mine area. The structural and mineralogical complexity of this area makes hydrogeological interpretation difficult.

Groundwater flow in the mine area is controlled by fractures and faults, preferred channels within debris flow material, and differences in hydraulic conductivity between bedrock, mine waste rock piles, and valley fill/alluvium. Hydrogeologic units are a Pre-Cambrian aquitard, volcanic and sedimentary rock aquifers, and valley fill alluvial or debris flow aquifers. The waste dumps contain perched aquifers. Groundwater gradients are toward the Red River, except for the cone of depression created by mine dewatering. Fan delta deposits at the mouths of tributary canyons are the principal hydraulic connection between the river and up-gradient sources. During 1994 twelve monitoring wells were installed by Molycorp consultants (SPRI) at sites near the mouths of tributary canyons draining the mine area, and were screened in bedrock and fan delta aquifers. Sampling and water level measurements have been conducted jointly by NMED and SPRI.

Water sampled from wells, seeps, and the underground mine workings is derived from both natural and mine-related sources. The river is the primary discharge point for groundwater systems in the area, but the deep underground mine intercepts some of it, which is dewatered by pumping via the slurry line to the tailings impoundments at Questa. Thus water impacted by acidic drainage, from mine sources as well as natural scar areas, is discharged by natural drainage to the Red River and by pumping and pipeline flow to the tailings area.

3.2.2.1 Water Quality of Seeps and Red River

Although more than twenty individual seeps have been identified along the north side of the Red River between Questa and Molycorp, there are three principal areas of concern where seepage is concentrated and appears to have the most significant impact on water quality - Capulin Canyon, Portal Spring, and Cabin Spring (Figure 7). Although water chemistry varies between seepage areas and is somewhat site-specific, all are acidic (pH ranges from 2 to 5) and contain elevated concentrations (exceed NM groundwater standards) of sulfate, TDS, Al, Fe, Mn, Co, Cu, Ni, Zn, Cd, and Fl (Table 1). Of the three seepage areas mentioned above, the one at Portal Springs (#40 and 41 in Table 1, POS-1 in Table D2 of Appendix D) is located nearest to Molycorp sources, being situated within a hundred yards of the toe of the Sugar Shack waste-rock dump complex. It is likewise located in proximity to the mouth of the Moly Tunnel (hence the name Portal Spring). Portal Spring was discovered by the author on January 19, 1994. In previous inspections of the area no seepage was observed in this location. Following consultation with Molycorp it was realized that this represented a newly emerged seep; it has been flowing perennially since January 1994. The Molycorp workplan for placement of monitoring wells was consequently modified to include characterization of this area.

The Cabin Springs seepage area is located 0.5 mile south/southwest of the Sugar Shack dumps, and the Capulin Canyon seepage area is located approximately 1.5 miles southwest of the dumps in upper Capulin Canyon and Goathill Gulch. As discussed previously in Section 2.3.1.1, the orientation of these seep areas in relation to Molycorp waste dumps (ie, located southwest of the dumps) is important information, given the well-documented occurrence of dominant geological structures/fractures trending northeast/southwest throughout the mine area. Although groundwater flow in valley fill and fan delta deposits may contribute ARD to the seeps along Red River, the role of bedrock fracture flow as a pathway between mine waste sources and the river seeps cannot be overlooked (Cabin Springs is solely fracture flow). In addition to the waste rock dumps, the open pit and underground mine workings at Molycorp should be considered as ARD sources that may impact water quality of Red River seeps.

Stiff Diagrams of major ions and metals were plotted by SPRI for water samples, including the seeps at Capulin Canyon, Portal Spring, and Cabin Springs (Appendix D). All three seep areas are characterized as calcium sulfate waters. Seasonal changes in seep water (or in the monitoring wells) is not yet well known (the Capulin seep has been sampled by this project a total of five times; see Table 1, map location #'s 37,46,50,63,66). The Capulin seeps exhibit the worst water quality, followed by Cabin Springs and Portal Spring. The dominant metals in all seeps are, in order of concentration, Al, Mn, and Fe. An unusual feature of the seep area that extends for hundreds of yards along the river at the mouth of Capulin Canyon is the segment of old (abandoned) river channel that now collects highly acidic seepage (see illustrations). The Capulin channel seep exhibited the highest concentrations of the four metals (Al, Mn, Cu, Be) that were documented at concentrations at least three times background (well at Red River WWTP) in data from NMED Superfund Oversight Section (NMED, October 23, 1995, p.16). During field work in the area on September 21, 1993, highway construction activity had caused an excavation on the north shoulder of the road opposite the mouth of Capulin Canyon. Water was present at a depth of six feet, representing the water table. The water was sampled (#35 in Table 1) and measured with a pH of 3.9 and a conductivity of 2450 umhos/cm. This water is presumably indicative of water quality of seepage before it emerges and is diluted with river water in the alluvium adjacent to the river. As a demonstration BMP a group of three anoxic limestone drains was installed by this project during October 1995 in this area to neutralize and treat acid drainage in the seeps at Capulin Canyon. Details of this BMP are given in the discussion in Section 4.2, and in Appendix H.

New seeps continue to come to our attention. At the end of this project in December, 1995, a previously undocumented seep was reported to the SWQB by a group of concerned Questa citizens. Located approximately one mile upriver of the Molycorp mill on the north bank of the Red River, this seep exhibits a pH of 4.5 and a conductivity of 700 umhos/cm. It emerges from a pool in the river alluvium and flows approximately seventy five feet to the river, leaving a prominent trail of thick, white precipitate. Water quality samples were collected and submitted for analysis on December 15, 1995 (results will be forwarded to EPA when they are received from the lab).

The effects of the seeps on Red River water quality are known from observations and various river surveys and sampling by NMED and Molycorp. NMED data are derived from river surveys by the SWQB Surveillance and Standards Section (Smolka and Tague, 1987 and 1989), sampling by the Superfund Section for investigations at Molycorp between 1993 and 1995 (Appendix A), and sampling by this project (Table 1). Water quality data and impairment status for the Red River derived from the biennial CWA 305(b) Report to Congress has been compiled and summarized in a November, 1995 report by NMED/SWQB for submittal to the NM State Engineers Office (see Tables 5 through 8). Molycorp has employed Vail Engineering to conduct annual river surveys and sampling since 1992 (see Vail, 1993, as well as data in Appendix D - Table D3, and Appendix F -

Table 1.5). The US Geological Survey has also been measuring discharge and collecting water quality samples at various points on Red River for over twenty years. Published data is available from their Water Resources Data Book for New Mexico for the following years: 1964-65 at the Fish Hatchery (discharge, field parameters, anions/cations, trace elements); 1969-77, same as above; 1978-1982, at Zwergle Dam, Molycorp Mine, Questa, Fish Hatchery, and mouth of Red River (discharge, field parameters, anions/cations, trace elements); 1983-87, at Questa, Fish Hatchery, and mouth of Red River (for above parameters). There is no USGS data available for the period following 1987.

Molycorp mine and the majority of scar areas are located on the north side of the river. No known acid seeps occur on the south side. The watershed on the south side of the middle reach of Red River is relatively undisturbed. As Red River in this area is a gaining stream, some seepage probably enters the bed of the river unseen, in addition to the visible seepage along the river banks. Acid seep areas are visible due to precipitation of white and red-colored mineral deposits and occasional growth of green algae in the seeps. All the acid seeps produce a prominent plume of white precipitate that coats river substrate, in some cases for scores of yards in a downstream direction (see illustrations P-11,12,19). At the Capulin seeps iron compounds precipitate out of solution first, and deposit a rust-colored precipitate for several feet around the emergence point, followed by much larger areas of the white precipitate. X-ray diffraction analyses have shown the white precipitate to be a combination of aluminum hydroxide and amorphous aluminum silicate compounds (personal communication, R. Vail). It is these aluminum compounds that, in suspension and solution in river water, are largely responsible for producing the milky-blue color that is commonly observed in the river between Molycorp and the Fish Hatchery (more pronounced during winter and spring months - see illustration P-6,11,19). Anecdotal evidence in the form of testimony by long-time residents claims that the river did not turn blue prior to the 1970's. Molycorp commenced large-scale, open pit mining in 1965. USGS seepage studies in 1965 and 1988 indicate that groundwater seepage to Red River below the Molycorp mine increased substantially between the two dates, which span the period before and after open pit development (unpublished draft Open File Report 95-1, NMONRT).

The mechanism for precipitation of minerals/metals by the seeps is controlled by changes in solubility brought about by pH buffering as a result of dilution by the river. The highly acidic groundwater can dissolve and transport elevated concentrations of contaminants, but when the seeps emerge and mix with river water the pH is raised and dissolved constituents begin to deposit. Aluminum has a double solubility curve (ie, it is soluble at both low and elevated pH values), and is therefore present as precipitated deposits on substrate and as dissolved and suspended aluminum compounds carried in river water. The combination of cemented river substrate (resulting in impacted benthic habitat), increased acidity, and elevated concentrations of dissolved and suspended phase contaminant loads has cumulatively impacted the aquatic habitat of the middle reach of Red River. If the river is sampled at mid-stream at some distance below a seep the dilution effect is such that water quality impacts appear minimal, but sampling closer to the river bank below a seep produces evidence of greater chemical changes. The cumulative impact becomes obvious and significant when one considers the steady degradation in water quality progressing downstream from the Town of Red River, past the scars and Molycorp, to the Fish Hatchery below Questa. In this stretch of river there is a progressive decline in pH and a corresponding increase in conductivity; TDS ranges in value from <100 mg/l upstream of the Town of Red River to >250 mg/l in the vicinity of Molycorp at Sulfur Gulch. During runoff events many dissolved (and total) constituents in the Red River exceed New Mexico numeric stream standards. In the 1994 New Mexico WQCC Water Quality [305(b)] Report to Congress, the Red River is listed as exceeding chronic criteria for Al, Zn, and Cd (Table 18, B-5). According to data from river samples (dissolved constituents) collected during base flow conditions by NMED Superfund Oversight Section and by Molycorp consultants on various dates, chronic criteria have been exceeded for Al, Zn, Cu, and Cd (Appendix D, Table D2 and D3; Appendix F, Table 1.5; and Appendix A, Tables 15,16,17). Although no numeric stream standard exists for Mn (despite an erroneous statement to the contrary by Molycorp in Appendix D, page D-13), there is a significant increase in mean concentration of dissolved Mn from above Molycorp property (0.1 mg/l) to below Molycorp at the USFS Ranger Station (.64 mg/l). For the above reach of river mean concentrations of dissolved Zn increase from .05 mg/l to .11 mg/l. The subject of contaminant loading rates to the river is further discussed in Appendix F (Table 1.6). Garrabrant (1993) lists the following constituents that have been documented in excess of State standards in the Red River by the USGS and NMED: pH, TDS, turbidity, sulfate, total phosphorus, Al, As, Ba, Cd, Cu, Cn, Fe, Pb, Mn, Mo, Ag, and Zn. Appendix G shows figures from Garrabrant illustrating ranges of concentrations of certain analytes.

Samples of streambed sediments collected by NMED Superfund Oversight Section in 1994 further document a release of contaminants to the Red River in the reach encompassing Molycorp Mine (NMED, October 23, 1995, p.23) (Table 18 of Appendix A). This contamination could be due to suspended sediment or precipitation of metal oxides from seeps. The metals Be, Cu, Pb, Mn, and Zn were elevated above three times background concentrations in at least four of the eight downstream sample locations. The elevated concentrations generally increased in a downstream direction. These same metals were most elevated in soil samples from Molycorp waste rock dumps relative to scar material (Table 4 of Appendix A).

In their geochemical assessment of ARD potential, Molycorp consultants conclude that acid generation is occurring in the waste dumps and is a relatively young process in some of the dumps. Over time those dumps (especially the ones closest to the river) have the potential to produce more ARD or worse-quality ARD, resulting in increased sulfate and metal loads in local springs and seeps (Steffen, Robertson, and Kirsten, April 19, 1995, p.35). That report further states that the seeps at Capulin Canyon are impacted by mine waste drainage that occurred prior to construction of the seepage collection system in upper Capulin Canyon in 1992.

3.2.2.2 Mine Water Quality

Discussions of water quality from mine waste-rock dumps seepage and groundwater in the underground workings are presented in excerpts contained in Appendices D and F, and NMED data for waste dump seepage is shown in Table 13 of Appendix A. Water samples have been collected from the collected seepage (leachate) at the waste dumps in upper Capulin canyon and Goathill Gulch, from several bedrock seeps occurring in Capulin Canyon, from seepage that infiltrates into the open pit, and from several locations within the underground workings (Shaft No.1 and the Decline). The worst water quality by far (in fact, the worst water observed at any location within the watershed) is the leachate that flows from the bases of the waste-rock dumps in Capulin Canyon and Goathill Gulch. Molycorp collects and diverts approximately 70 gpm of this collected leachate into the underground mine via the caved area in Goathill Gulch. This seepage is acidic (pH values of 2 to 3), has TDS values of approximately 25,000 mg/l, sulfate concentrations are in the 13,000 mg/l range, has very high levels of Fe, Mn, Zn, and Al (ie, dissolved aluminum is present at concentrations ranging from 1,1000 to 1,300 mg/l). On Stiff Diagrams (Appendix D) these seep waters are calcium and magnesium sulfate water, with occasional high Al or Fe exceeding the Ca/Mg. Tritium analyses of selected water samples on Molycorp property indicate that seepage from waste rock dumps is post-1952 in age (Appendix D). Preliminary data (from a very limited data set) from experiments with Pb and Sr isotopes indicates that dump seepage may have a different signature than natural acid seeps (SPRI, April 21, 1995, p.D-12). In evaluating the chemistry of seepage from the waste rock dumps it is important to consider that some of the dumps either overlay existing scars or contain scar material (altered volcanics) that was former overburden in the open pit area. Therefore the chemistry of seep waters from scar material needs to be understood and accounted for in any analysis of the water quality at mine waste sources. Water quality of scar areas (located both within and without the Molycorp mine area) is discussed in Section 3.2.2.3, and comparisons are made in Section 3.2.2.5.

Water representative of drainage from disturbed, acid-generating material in the open pit was acidic (pH <3) and contained high concentrations of sulfate, Al, Fe, Mn, and Zn. Samples of groundwater collected at various locations in the underground mine workings represent a mixture of ambient groundwater, oxygenated vadose water, and ARD introduced from the open pit drainage plus the waste-rock dumps seepage collection system. Groundwater samples from the Decline and Shaft No.1 thus represent diluted ARD discharges. Samples from these locations are near neutral pH, have TDS concentrations between 2,000 and 3,000 mg/l, and equal or exceed State Groundwater standards for sulfate, Al, Fe, Mn, and Cd. Fluoride concentrations exceed EPA MCLs. The current dewatering of the mine (pumped to the tailings impoundments) creates a cone of depression in the water table that may prevent some water containing the above listed contaminants from discharging to the Red River. Increased seepage inflow to the Red River in this reach, however, suggests that cone of depression is not capturing all water (NMONRT, 1995). Discharged at the tailings impoundments, a portion of these contaminants likely, over time, end up in the Red River downgradient of that location via seepage losses.

In the most recent and comprehensive geochemical assessment of the mine area, Molycorp consultants conclude that the main sources of ARD from Molycorp getting into the river are the waste-rock dumps in upper Capulin Canyon and those dumps adjacent to the Red River (Sugar Shack South, Middle and Spring and Sulfur Gulch), through alluvium and geologic structures of high hydraulic conductivity (SRK, April 13, 1995, p.11).

3.2.2.3 Scar Water Quality

Analytical data for water samples collected from scar areas exists for stormwater runoff and, more germane to this project, for seepage of ARD-influenced groundwater from the scars. The nature and distribution of scars in the watershed is discussed in Section 2.3.2. The most recent comprehensive investigation of the geochemical properties (ARD potential) of scars is found in the report for Molycorp by Steffen, Robertson, and Kirsten (SRK, April 19, 1995), which is excerpted in Appendix F. Other data from Molycorp for seepage samples from scar areas in Hansen Creek, Haut-N-Taut Creek, Goathill Gulch, and Capulin Canyon are presented in Appendix D (see samples CCS-2, CCS-4, GHS-3, HCS-1 and 2, HTS-1). NMED data for scar area water samples from this project are in Table 1 (#28,29,30,45,57,64,65). Other NMED data, from the Superfund Section's investigation of Molycorp, are in Appendix A (Tables 3,4,6,7, and 13).

Due to oxidation of sulfide minerals (mainly pyrite) in the scar areas, ARD is generated and has been documented in samples of both runoff and seepage waters. All such samples exhibit acidic pH (in the 2 to 4 range), high concentrations of TDS, sulfate, Al, Fe, Mn, Cu, Zn, and Fl, with other trace elements present, including Cd, Co, Cr, and Ni. Average concentrations of metals (in mg/l) in samples of seepage from the scar areas in Hansen Creek and Goathill

Gulch include the following: Al=163, Fe=484, Mn=42, Zn=9, Cu=3 (Appendix A, Table 13). In groundwater sampled from two private wells located on Bitter Creek, which are probably completed in debris flow material associated with scars, standards were exceeded for Al, Cd, Co, Fe, and Mn (Table 1, #28 and 29). The drainage from the Hansen Creek scar area contained concentrations of Al, Co, Fe, Mn, and Ni in excess of standards (Table 1, #45 and 64). The production well at the Red River waste water treatment plant is completed in scar area debris flow material, and consequently has poor water quality (Appendix A, Table 6).

3.2.2.4 Mine Monitoring Well Water Quality

In 1994 twelve new monitoring wells were installed by Molycorp in the vicinity of the mine to evaluate the impacts of mining operations on surface water (Red River) and groundwater, and to evaluate the relative contributions of natural versus mining-related sources on water quality impacts. A summary of the installation and testing of these wells is contained in Appendix C. Aquifer tests and water quality sampling have been conducted by SPRI for Molycorp (summarized in Appendix D) and water quality sampling has been conducted by NMED (see Appendix A and Tables 1 and 2). Locations of these wells are shown in Appendices C and D, and in Figure 6. Wells were sited in order to define linkages between sources and river seeps, and results are best described in that sense.

Wells MMW-10A,-10B,-10C, and -11 are between the Sugar Shack South waste-rock dump and Portal Springs. These wells contain calcium sulfate water that is acidic (pH 4.7 to 5.8) and concentrations of TDS ranging from 1400 to 2000 mg/l and sulfate in excess of 1000 mg/l. Water chemistry of these wells is similar to the Portal Springs seepage, and Tritium analysis indicates a post-1952 source. State groundwater standards are exceeded in these wells for TDS, sulfate, Al, Cd, Co, Cu, Mn, and Ni.

Wells MMW-7,-8A, and -8B are meant to evaluate the possible flow path along the unnamed tributary canyon east of Shaft No. 1 that could convey water between the Sugar Shack West waste-rock dump, the east end of the Goathill Gulch waste-rock dump, and the river. MMW-7 contains magnesium aluminum sulfate water that is acidic (pH 4.4), has very high conductivity (16,000 mg/l) and sulfate (9366 mg/l), and exceeds groundwater standards for the following metals: Al, Cd, Co, Cu, Fe, Pb, Mn, and Ni. It is similar to the waste-rock seepage at Capulin Canyon and Goathill Gulch. NMED Superfund data show that MMW-7 water samples exceeded three times background concentrations (in water from the underground workings) for the CERCLA metals As, Cd, and Cu (NMED, October 23, 1995, p. 16). Water from wells MMW-8A and -8B, which are located closer to the river, is not as acidic (pH 6.4 and 8.2) and contains moderate TDS concentrations (2200 and 1100 mg/l respectively). Metal concentrations are low. A possible relationship between water from the perched zone in MMW-7 and that seeping from a similar perched zone at Cabin Springs is suggested. Tritium analysis indicates Cabin Springs seepage is post-1952.

Wells MMW-2 and MMW-3 are in lower Capulin Canyon along a likely flow path between the waste-rock dumps in upper Capulin Canyon and the acid seeps at the confluence of Capulin Canyon and Red River. Water from these wells is classified as calcium sulfate water. Well MMW-2 is in valley-fill and contains acidic water (pH 4.9) with a TDS of 3400 mg/l and sulfate concentrations of 2177 mg/l. MMW-2 contains the following metals in excess of standards: Al, Cd, Co, Fe, Mn, Ni, and Zn. Well MMW-3 is completed in bedrock and contains water that is not acidic (pH 7.5) but has elevated concentrations of TDS (2900 mg/l) and sulfate (1759 mg/l). Metals exceeding groundwater standards are Co, Mn, and Ni. Water in MMW-2 resembles somewhat the surface flow in Capulin Canyon that infiltrates the alluvium about 1000 feet up-gradient (sample CCS-4 in Appendix D, Table D2). In the Stiff diagram in Appendix D (D7A) there is a correspondence in the ratio of metals concentrations between water from the Capulin waste-rock dump seepage (CCS-1), well MMW-2, and the seepage at the mouth of Capulin Canyon (CCS-6). Relative concentrations decrease in the order given, as would be expected, with increasing distance from source to seep.

3.2.2.5 Comparison of Water Quality Results

In comparing water quality results from sampling in the Molycorp mine area and the hydrothermal alteration scar areas, the principal concern is distinguishing between water contaminants derived from mine wastes and from natural (mineralized) scar areas. To date, the best information of this type is found in the geochemical assessment by SRK dated April 13, 1995 (Appendix F), and in the data tables prepared by Stuart Kent of the NMED Superfund Oversight Section in the Expanded Site Inspection Report (Draft Document) on the Molycorp Site dated October 23, 1995 (data tables are in Appendix A). These reports and data show that water from mine-related sources, especially the waste-rock dumps, contains significantly greater concentrations of sulfate and metals (Al, Fe, Mn, Zn, Cu, Cd) than water from the scar areas. Water from both types of sources is similarly acidic; pH ranges from 2.3 to 3.6. The most significant ions at increased concentrations in mine waste drainage are sulfate, Al, Mn, and Zn.

In Kent's discussion of the groundwater pathway and methods of attributing a release to the two aquifers from Molycorp sources (NMED, October 23, 1995, p.18), he first compares data between background samples at the Red River WWTP well (which is screened in scar-derived mudflow material, and is thus a conservative estimate for background) and samples from down-gradient seeps. This approach demonstrates a release (concentrations three times background) of the metals Be and Cu to the alluvial aquifer (Table

6 of Appendix A). A second method compared down-gradient seeps (below Molycorp) to an up-gradient seep originating from a scar area at Hansen Creek. The data show over a three-fold increase in Be, Al, Cu, and Mn in the down-gradient seeps (Table 7 of Appendix A). To further support this attribution, leachate from mine wastes showed greater concentrations of Be, Al, Cu, and Mn than from scar material (Table 13 of Appendix A), and Cu and Mn were detected at twice the concentration in soil samples from waste dumps than in scar areas (Table 4 of Appendix A). Data from other studies by Molycorp consultants support these findings (Vail, July 9, 1993, Appendix 1). Kent also presents data showing a release of As, Cd, and Cu to the fractured bedrock aquifer that is at least partially attributable to Molycorp (see data for well MMW-7 and Cabin Spring in Table 8 of Appendix A). Attribution is reasonable to assume because Cd and Cu are present at greater concentrations in both soil and leachate from waste dumps as compared to scar areas (Tables 4, 13, 14 of Appendix A).

In Capulin Canyon there are elevated concentrations of Zn in shallow alluvial water (9.48 mg/l) as well as in the waste-rock seepage (130 mg/l), while seepage from the "scar area" (as identified by Molycorp) in Capulin Canyon has low concentrations of Zn (2.08 mg/l). These data suggest that the shallow alluvial water in Capulin Canyon (and by extension, the seeps at Red River) are impacted by waste-rock ARD (Steffen, Robertson and Kirsten, April 13, 1995, p.14).

In comparison to concentrations of Al and Mn in drainage from scar areas, the drainage from waste rock in Capulin Canyon and Goathill Gulch contains up to an order of magnitude increase in concentration of Al and Mn (SRK, April 13, 1995, p.28). From the same report (p.29), it is stated seepage from acid-generating waste-rock can be anticipated to have higher concentrations of sulfate, Al, Zn, and Ni, with respect to seepage from undisturbed scar material. Only Fe is present at greater (average) concentrations in seepage from scars than waste-rock. Fluoride is present at elevated, but roughly similar, concentrations in mine waste and scar drainage.

3.2.2.6 Acid Rock Drainage Assessment

Acid rock drainage (ARD) from Molycorp mine waste and the hydrothermal alteration scars in the watershed has been well documented in many previous investigations in the area. The temporal effects of runoff and the persistent adverse effects of base-flow seepage to groundwater and the Red River have been described here in Sections 2.3 and 3.2. Analytical data for water samples presented in Tables 1 and 2, and Appendices A, D, and F all confirm that the Red River and groundwater that recharges the river are being impacted by elevated concentrations of TDS, sulfate, Fl, and dissolved metals (Al, Fe, Mn, Cu, Zn, Cd, Co, Cr, Ni, and Pb). The latest and most comprehensive investigation of ARD from

Molycorp Mine and surrounding area is a geochemical assessment performed by the consulting firm of Steffen, Robertson, and Kirsten in 1994-1995 (SRK, April 13, 1995). Their data and conclusions are summarized in Appendix F, and below.

Samples of scar material collected in and adjacent to the mine area possess significant acid generating potential. The scars produce runoff and drainage water with elevated concentrations of sulfate, Fl, Al, Cu, Fe, Mn, Cd, Co, Cr, and Ni, plus a high soluble salt load.

At the mine, samples of mixed volcanic waste rock also show significant acid generation potential and current acid generation from material excavated from Sulphur Gulch during open pit construction. This material is now in the dumps located north, south, and west of the open pit, and also remains exposed in the west pit wall. The suite of contaminants is similar to those given above for scar water, but are present at significantly greater concentrations in drainage from mine waste, probably due to a greater degree of disturbance (from blasting, excavation, and disposal) and hence greater surface area within waste-rock dumps for oxidation and ARD generation. Particularly, ARD from waste rock contains higher concentrations of sulfate, Al, Zn, and Ni (SRK, April 13, 1995, P.29). A portion of the open pit waste rock consists of andesite/aplite/granite, which is shown to have limited potential for leaching of sulfate and metals. Similarly, development rock from the old and new underground workings indicate low potential for acid generation, but some exposed cut slopes within the new mine currently exhibit acid generation. The relict tailings from the old mine that are located near the mill indicate current acid generation and the potential for leaching of metals and sulfate.

The hydrothermal scars represent a mature source of ARD (the oxidation process has been taking place over geologic time), and therefore the potential for acid generation is relatively constant as erosion exposes fresh, un-oxidized material. Mine wastes however, due to the recent disturbances and resultant increased surface areas available for the oxidation process, represent new and enhanced sources of ARD. Thus many of the waste rock piles can be expected to generate ARD of worsening water quality in the future and for an indefinite period of time. The potential for increasing concentrations of sulfate and metals to the Red River exists for the mine waste seepage in Capulin Canyon, subsurface seepage from the new underground mine and the old tailings at the mill site, and seepage from the waste rock dumps at Sugar Shack South, Middle and Spring and Sulphur Gulch (SRK, April 19, 1995, p. 38). Although numerous acidic seeps are known to occur along the Red River near the mine, the exact location of seepage plumes in relation to waste sources is currently unknown, as is the relative contribution of the sources. There is little doubt, however, that seepage of ARD-influenced groundwater through the waste-rock piles can reach the Red River through the shallow alluvial aquifer and upper fractured bedrock perched aquifers, and therefore has an adverse impact on the quality of the springs and seeps adjacent to Red River. The following quotation is taken from the geochemical assessment by SRK (April 19, 1995, p. 35): "Over time, ongoing acid generation in the waste rock disposal areas adjacent to Red River, and the consumption of the neutralizing potential of the waste rock, and consumption of the remaining attenuation capacity in the alluvium in seepage flow paths has the potential to increase sulfate and metal loads in local springs and seeps".

3.2.2.7 Contaminant Loading Rates and Groundwater Recharge Rates

The subject of contaminant loads affecting Red River has been initially addressed in Section 3.2.2.1 and recharge rates to Red River have been touched on in the discussion of the hydrology of the Molycorp Mine area in Section 2.3.1.1. Estimates of contaminant loading and recharge rates to the Red River have been made in previous reports (Vail, 1993; SPRI, 1993 and 1995; SRK, 1995; NMED, October 23, 1995); all use sulfate concentrations as a proxy for metals, along with USGS flow measurements on which to base their analyses.

The average annual discharge of the Red River at Questa Ranger Station is approximately 41 cfs (Vail, 1993). Discharge ranges from 7.74 cfs to 262.5 cfs have been measured by USGS over a twelve year period. In the middle reach of the Red River, seepage studies by USGS have documented accretion from groundwater into Red River at approximately 4 cfs. Therefore a portion of the 2 cfs that comes from the north side of the river originates from the drainage area of Molycorp Mine. Other studies by SPRI (April 21, 1995) estimate groundwater recharge to the Red River from the Molycorp Mine area to be between 1.45 and 2.56 cfs. The most conservative estimate is based on the Molycorp Mine area being 6% of the total area of the Red River watershed. Assuming uniform distribution of recharge (this is questionable) and an average baseflow of the Red River at 11.04 cfs, the mine area would contribute 0.66 cfs of groundwater accretion to Red River. To further complicate an already confusing array of estimates, arguments are made by Molycorp consultants that cyclic patterns of precipitation and discharge in the region have the potential to affect groundwater recharge rates to the Red River (SPRI, April 21, 1995, B-5; SRK, April 19, 1995, pp 19 and 39). While this is a reasonable hypothesis, local seepage increases and decreases at the sub-watershed scale suggests that other forces are at work as well (NMONRT, 1995).

An analysis of groundwater accretion to Red River based on data by USGS in their two seepage studies in 1965 and 1988 indicates there was approximately 31% more accretion in 1988 than in 1965 (NMONRT, November 29, 1995, Draft OFR 95-1). A notable difference occurs in the reach between Columbine Creek and the Questa Ranger Station, where groundwater seepage inflow increased 149% between 1965 and 1988 (from 2.1 cfs to 5.2 cfs). Both seepage studies were conducted under similar flow conditions in the month of November, and at the same approximate stations. The major change in the watershed was that in 1965 there was no open pit at Molycorp, whereas in 1988 the pit and associated waste dumps had been in place for more than twenty years. This suggests the possibility that increased seepage to Red River below the mine area could be due to enhanced groundwater recharge resulting from interception of water by the pit and dumps. Additionally, in recent years Molycorp has been diverting nearly all stormwater runoff from the mine site to the pit, caved area, and a number of retention ponds, all of which may enhance groundwater recharge.

The ratio of seepage flow to stream flow for a given reach has important implications for water quality of the river. In the example given above, seepage flow was 7.9% of stream flow in 1965 but was 16.4% in 1988. In other words seep flow was diluted by 12 to 1 in 1965 but by only 5 to 1 in 1988 (ONRT, November 29, 1995).

An understanding of the relative contribution of scar area sub-watersheds to the contaminant loading of Red River is only beginning to take place. For example, the Hansen Creek sub-watershed (located east and up-river from Molycorp) covers 0.11 square miles, of which approximately 0.08 square miles is scar area. In base flow the average surface and sub-surface contribution to Red River is approximately 0.1 cfs. (SRK, April 13, 1995, p.20). More data of this kind, along with water quality, are needed in order to accurately model and predict the relative contribution of contaminants to the Red River from the mine and the scar areas.

Groundwater recharge rates to the Red River are determined by aquifer characteristics such as transmissivity and hydraulic conductivity. These hydrogeologic parameters have been measured in pumping tests at some of the twelve new monitoring wells installed in the mine area since 1994 (SPRI, April 21, 1995 and Appendix C). As stated earlier, there are two main aquifers in the mine area; a fractured igneous and volcanic bedrock aquifer, and an overlying alluvial/colluvial aquifer. Based on pumping tests, these aquifers are considered interconnected. The hydraulic conductivity of the fractured bedrock aquifer is reported between 5.1 gallon/day/square foot and 629 gallons/day/square foot, and the alluvial aquifer was 1,141 gallon/day/square foot (SPRI, April 21, 1995, B-9). That hydraulic conductivity ranges over two orders of magnitude for the bedrock aquifer is a function of the degree of fracturing present.

Estimates of groundwater travel time (seepage velocity) between the caved area in Goathill Gulch and Red River have been calculated to be approximately 0.48 foot/day, or 19.97 years from the caved area to the Red River (SPRI, April 21, 1995, B-11). This travel time is a rough guess, and could be considerably shortened by preferential pathways such as faults and fracture zones that cut across the structure of the mineralized zone.

Estimated loading rates for sulfate and selected metals are shown in Table 1.6 of Appendix F. At low-flow conditions in the Red River, the loading rate for sulfate increases from 2768 kg/day above Molycorp mill to 8741 kg/day below Capulin Canyon. Correspondingly, similar increases occur in this reach for TDS, Fl, Al, Mn, Fe, Cu, and Zn. Mass loading of sulfate, Al, and probably most other analytes present in the sources is more significant during low-flow conditions in Red River. This is logical since significant dilution of seep and spring discharges occurs during higher river flows.

In their evaluation of sulfate gains and contaminant loading to Red River, the various Molycorp consultants have concluded that the increased loading rates between the mill and the Questa Ranger Station either: (1) cannot be ascribed with certainty to mine wastes or scars, (2) are due primarily to scars, or (3) are a result of climatic variability. NMED believes the documented increases in contaminant loading in the middle reach of Red River are due in large part to the increasing generation of ARD from Molycorp waste-rock piles, sulfide-rich material in the open pit and underground mine workings, and relict tailing deposits at the mill. In support of this view that contaminant loading in the middle reach of Red River is largely attributable to Molycorp sources are the data and preliminary evaluation of sulfate gain by Kent (NMED, October 23, 1995, Draft Document) (Appendix A). This approach used eight data sets covering a period of 29 years, and focused on the reach of river solely between Molycorp property and the Questa Ranger Station. Significant increases (up to 80% of total gain) in sulfate in the lower half of this reach seem to coincide with creation of the waste rock dumps from the open pit operation, and then abruptly decreased to 52 % of total gain in 1992 when the Capulin collection system was installed and cut off much of the surface flows in the two tributaries of Capulin Canyon and Goathill Gulch. A subsequent increase suggests a new source for sulfate has developed since 1992. The present project has observed that new sources of ARD-influenced groundwater recharge are in fact developing along the Red River; the author documented a significant newly-emerged acid seep opposite the Moly tunnel in January, 1994 (sample numbers 40 and 41 in Table 1, Portal Spring samples in various Molycorp reports and data tables). Since scar areas are not likely to have increased in size or acid generation since 1992, it is reasonable to assume the increase in sulfate is probably due to groundwater recharge impacted by mine waste sources. This postulate is further illustrated by the plotting of sulfate versus stream discharge shown in Appendix A (from NM Office of Natural Resource Trustee, Draft Document). It clearly shows increased sulfate input at lower flows, and that groundwater input has increased since 1965. The emergence of some of the acid seeps along the river is currently controlled, in part, by the cone of depression in the regional (bedrock) water table caused by pumping/dewatering of the mine. A post-mine rewatering configuration of the water table has been estimated. If pumping/dewatering ceased, points of discharge from the underground workings would be the Moly tunnel (also known as the 7960 adit) and through the alluvium south of the caved zone in Goathill Gulch (SRK, April 13, 1995, p.18). In order to avoid increased acid seepage to the river, or direct discharge of mine water to the river, this scenario should probably be avoided, which implies perpetual pumping of the mine or perpetual treatment of seepage points before the water enters the river.

3.2.3 Other Mining Sites in the Red River Watershed

Based on field reconnaissance and a review of the sources listed in Section 3.1.4, it was determined that Bitter Creek, Pioneer Creek, and Placer Creek contain the greatest concentrations of old mining sites among the seven tributaries where mining activity has occurred within the Red River watershed. The distribution of these sites (mines, mills, prospects) is as follows:

Tributary	Total Sites	Sites with seepage	Sites with mills
Bitter Creek	17	4	5
Pioneer Creek	16	3	1
Placer Creek	14	3	4
Cabresto Creek	6	0	0
Goose Creek	5	0	0
Black Copper Cyn	1	1	1
	59	11	11

In addition to these sites located on tributaries there were formerly several mill sites and smelters located adjacent to the Red River in the area of the present town (Copper King Mine and smelter, June Bug Mill, and Sampson Mine), but nothing remains of these operations today. All of the sites listed in the table above were fairly small operations, therefore associated waste piles are relatively minor. No mine in the Red River district produced more than a few hundred tons of ore, except the Memphis Mine on Bitter Creek, which produced 3500 tons of ore (Roberts, et. al, 1990). Most of the work in the district was development and exploration.

In Bitter Creek the significant sites are the Memphis, Anchor, Midnight, and Oro Fino. All waste dumps are small scale, although some are in the flood plain of Bitter Creek (e.g., the dump at Midnight Mine is 7400 square yards, and at Anchor Mine is 2800 square yards). The Oro Fino Mine is the site with the most significant discharge of ARD. An anoxic alkaline drain was installed here in 1994 as an experimental BMP, and has resulted in a dramatic improvement in water quality (Table 1). The majority of mine waste accumulations on Bitter Creek represent a source of nonpoint source contamination to the stream (sediment, TDS, sulfate, metals, and in some cases acidity) during runoff-producing events, but have little or no impact on the creek during normal weather (base flow conditions). Even the ARD from the Oro Fino (before BMP) had a negligible effect on the water quality in Bitter Creek due to low seepage rates and dilution effects.

The same observations hold true for sites in the other tributaries. Seeps were evaluated by measuring field parameters (pH, electrical conductivity, DO, temperature); none were found to exhibit significant flows of degraded water quality (pH values ranged from 5.5 to 7.0 and conductivity from 115 to 2400). The largest site on Pioneer Creek was the Caribel Mine and mill, which was dismantled in 1980.

In summary, although many of the sites contribute some nonpoint source contamination to nearby surface waters during runoff events, none of them appear to represent a significant source of ARD discharge to either groundwater or to streams. Taken as a whole, the cumulative impacts to water quality in the upper reaches of the Red River and its tributaries from these old mining sites is relatively insignificant in comparison to the much greater sources of the scar areas and Molycorp Mine in the middle reach of the Red River.

3.2.4 Leaking Underground Storage Tank Sites

In Section 2.3.3 is given a description of the three known sites where underground storage tanks have leaked petroleum products, all within the town of Red River. Since the NMED Underground Storage Tank Bureau (USTB) has regulatory authority over investigation and remediation of sites contaminated by leaking USTs, the role of this project in regard to UST sites has been to consult with and maintain close communication with the appropriate technical staff in the USTB about progress at the three known sites in the Red River watershed. Their files were copied and incorporated into the records for this project, and site visits were coordinated with USTB staff for all three sites in Red River. Quarterly monitoring reports, data, and consultants reports are provided to this project as they are received by USTB staff. Frequent inspections have been made for evidence of hydrocarbon release at the Chevron Red River site, where past discharges to the river through a storm sewer have been observed. Subsequent and ongoing remediation at this site has been effective in containing and treating contamination. No evidence of hydrocarbon contamination reaching Red River has been found, either in sample data or observation, since 1992.

In anticipation of road work and infrastructure changes along State Highway 38 through the Town of Red River, the NMHTD commissioned an environmental investigation along the right-of-way by Camp, Dresser, and McGee, Inc.(CDM) in 1994. CDM has completed several phases of investigation focusing on potential environmental hazards in the project area (basically the entire Main Street area of Red River), which included soil borings and monitoring wells at potential risk areas (CDM, Jan. 1994). Seven sites of potential concern were identified in Phase 1A: Diamond Shamrock station, Edelweiss Inn (former Texaco/Gulf station), Pioneer Lodge (former Phillips 66 station), Bittercreek Rentals (former Shamrock/Chevron station), Angelinas Restaurant (former Texaco station), High Country Rentals (former Chevron/Gulf station), Resort Realty (former Conoco station). Two of these seven sites (High Country Rentals and Bittercreek Rentals) have confirmed releases and are under investigation or remediation. At the other sites no hydrocarbon contamination has been detected in any of the soil samples collected from borings, and no groundwater samples have shown hydrocarbon contamination above regulatory action levels. Groundwater flow gradient was measured at 0.0073 ft/ft, in a direction of west to northwest.

3.2.5 Septic Tanks and Sewage Lagoons

As mentioned earlier in Section 2.3.4, the upper Red River valley (above the town of Red River) has become densely developed with subdivisions having hundreds of homes on small lots. During site inspections in 1994 an attempt was made to count the number of houses in this area. In the area between Fourth of July Canyon and Foster Park Canyon (an area of 1.5 miles x .25 miles) approximately 125 houses were counted. This area includes the Valley of the Pines Subdivision, which is the lowest one on the upper valley, and many of the houses are located very near the banks of the river. Others are built on very steep slopes that appear to have thin soils overlying bedrock. The subdivisions in the upper valley area above Fourth of July Canyon contain approximately 200 houses (difficult to count because many are in forest). An initial effort to quantify the septic tank situation was made by contacting the NMED Field Office staff in Taos, NM for information about liquid waste permits, which are required for construction of any household waste disposal system. The Environmentalist in charge of the Red River area (Bill King) indicated that such information would be meaningless because most builders in that area do not apply for the permit and install their septic tanks illegally. He had only received two requests for liquid waste permits in the last six months, and believed that many more houses than that had been built in that period. Enforcement is a problem. Other NMED staff from SWQB were told of concerns by a local resident about illegal installations by a local plumbing contractor in the area who was installing holding tanks (that should be pumped out when full) with holes punched in the bottoms. Strategies for documenting pollution in groundwater and the river include sampling the river near observed algal blooms, and sampling private wells for analyses of nitrate and TKN. Nitrate concentrations can be determined in the field by using one of the Department's Hach Kits, which use a colorimetric technique to quantify nitrate (10 mg/l is the NM groundwater standard). Efforts under the State's Liquid Waste Program are continuing.

During 1995 others expressed additional concern over potential problems in the upper valley, and began coordinating activities in this regard. Bill King (NMED, Taos Field Office) reported receiving increasing numbers of complaints from upper valley residents about failing septic systems. Bob Perry (Director of Public Works for Town of Red River) assumed a leadership role in the recently created Red River Watershed Association, and began to focus on the water quality impacts in the Upper Valley. From a coordination meeting between these parties in April, 1995, it was determined that there are approximately 450 houses in the upper valley now, with a capacity for about 1000 more in the future. Only [illegible] houses have been issued Liquid Waste Disposal Permits from NMED since 1973, implying that over 200 have illegal systems. It is assumed that there are at least 400 private water supply wells in the area. In order to curtail the installation of more illegal systems and to alleviate existing (probable) water quality impacts to the Red River from the upper valley, the Town of Red River would like to extend it's sewer and water service to the Upper Valley. The existing WWTP can handle the increased flow, and costs are estimated at approximately ten million dollars. The town is applying for assistance in funding this project, and hope for completion in about five years. In order to further document the need for this project, several activities will be conducted in the upper valley during the summer months of 1996 in joint efforts between the Town of Red River, the NMED Taos Field Office, and NMED/SWQB. A Water Fair will be held, during which residents can bring samples of their well water for testing and analyses (nitrate screening being used to indicate possible contamination with septic system wastes). To follow up on wells that may be contaminated, [illegible] and possibly dye traces will be conducted. Both banks of the river will be walked through developed portions of the upper valley to look for evidence of illegal direct discharges to the river and for signs of failing septic systems in proximity to the river.

The Questa sewage lagoons, described earlier in Section 2.3.4, fall under the regulatory authority of the NMED Ground Water Section, which reviews the required groundwater monitoring at the facility through a Ground Water Discharge Plan (DP-191). These analytical results, which have not revealed contamination above State standards, are on file with NMED-GWS. This project reviewed the DP-191 file and consulted with Ground Water Section staff, but did not see a need to conduct any further sampling or field work at this site. An additional lagoon cell was being planned for construction by Questa in late 1995 (personal communication, George Long, USFS, Questa RD).

IV. BEST MANAGEMENT PRACTICES AND REMEDIATION

4.1 REMEDIAL STRATEGY

In discussing solutions to groundwater nonpoint source pollution problems within a large watershed involving major mining sites with complex background issues, a distinction should perhaps be made between best management practices (BMPs) and remediation activities. Within the context of 319(h) projects, implementation of BMPs for improving water quality during the two-year period of the grant has traditionally been emphasized. Addressing multiple NPS sources, some of which are huge, complex mining sites, within a watershed of 226 square miles during a two-year period is unrealistic. Furthermore, it must be recognized that groundwater contamination problems typically require decades and often millions of dollars to correct or contain. Cleanup of some contaminated aquifers may in fact prove to be technically infeasible at the present time. Therefore, a remedial strategy must distinguish between short-term treatment or containment of symptoms versus long-term remediation activities aimed at complete site restoration that effectively and permanently deals with pollution sources. A remedial strategy that addresses mining sites must also employ different tactics in addressing abandoned sites and active ones. If Molycorp mine again becomes active (which now appears likely, see news articles in Appendix I), formulating and implementing remedial projects and a comprehensive site closure plan becomes a complex task involving many technical issues and several regulatory agencies (NMED Groundwater Quality Bureau, Surface Water Quality Bureau, Air Quality Bureau, and Superfund Section; NM Office of Natural Resource Trustee; and NM Mining and Minerals Division).

Treatment strategies need also to consider the separate but related mechanisms of contaminant transport (ARD vs. pulse event runoff) by which mining sites and scar areas are contaminating Red River. At the smaller abandoned mine sites in the tributaries, BMPs could probably be implemented that would effectively address both types of problems. Access may be a problem at some of these sites which are patented (privately owned under the 1872 General Mining Act). Effectively treating ARD-contaminated groundwater problems at a huge site such as Molycorp, or at most scar areas, will not be permanently solved by implementing simple BMPs. Interim treating of the symptoms with passive systems such as anoxic alkaline drains may be the only viable alternative while more expensive and long-term solutions for remediating the source of the problems are designed and implemented. The feasibility of trying to address scar area problems in general is being investigated by the Bitter Creek 319(h) Project. These are large, unstable, dynamic areas subject to rapid geologic processes that tend to dwarf human efforts at intervention. It may be determined that resources would be better utilized in solving other NPS problems in this watershed (e.g., cleaning up abandoned minesites, site reclamation at Molycorp, passive treatment of seeps, better enforcement of septic tank installations or connecting subdivisions to WWTPs, etc.).

Most water quality data for the Red River watershed was collected during base flow conditions. As efforts to provide improvements within the watershed increase, emphasis must be placed on monitoring discrete runoff events for given areas in order to more accurately characterize the effects of resource extraction activities on water quality. A long-term program of systematic BMP implementation to reduce or eliminate pulse event contamination from small minesites (and perhaps some priority scar areas) would be facilitated by more intensive monitoring and sampling at these sites for pulse events .

4.2 DEMONSTRATION PROJECTS for BMPs

During 1993 an appropriate site was sought to install a small-scale anoxic alkaline drain treatment system to treat ARD on a pilot project basis at a small minesite in the watershed. The Oro Fino Mine site on Bitter Creek (Figures 2 and 6) was selected for this demonstration project, which was installed in September, 1993. Funding and in-kind services for this project came from the Carson National Forest, NMED-SWQB, and Amigos Bravos, a conservation group in Taos. Based on two samples collected six months apart, this system has significantly raised pH and reduced concentrations of metals in solution from this water source (Table 1).

A larger version, up to 300 feet long, of an anoxic alkaline drain is planned for a portion of the large seep area near the mouth of Capulin Canyon. This system would be used as a pilot project for large scale remediation of ARD. A portion of this system was successfully installed during the period October 30 to November 1, 1995 (Appendix H). A total of 170 feet of trenches, in four segments, was completed during this time in a cooperative effort involving NMED-SWQB technical staff, Molycorp Mine, the NM Highway and Transportation Department (NMHTD), and the US Forest Service - Questa Ranger District. NMED staff (Dennis Slifer, Mike Coleman, Peter Monahan) provided planning, coordination, and oversight, photo-documentation, and sampling of water and soil samples. Molycorp Mine provided heavy equipment (track-hoe) and operator, and purchased the limestone and clay for the project (approximately $12,000). Because the project took place within the right-of-way of State Highway 38, the NMHTD provided clearance work, heavy equipment (backhoe, loader, dump trucks), and a crew of up to ten operators and traffic control personnel. The USFS expedited all necessary NEPA clearance (the project is located within the Carson National Forest). The trenches were excavated 13 to 15 feet deep and 5 to 8 feet wide. Acidic groundwater was encountered, along with areas of oxidized iron-stained soil, in all trenches at depths of approximately 10 to 12 feet. Samples were collected and submitted for analysis (results are pending). The trenches were filled with approximately 4 to 5 feet of limestone cobbles, followed by a 16-mil plastic liner and several feet of bentonitic clay, with the remainder backfilled with overburden to grade. The disturbed areas were seeded and mulched the following week. A more comprehensive report accompanied by design specifications is in Appendix H. The seeps are being monitored frequently for signs of improvement. Subsequent data and an evaluation of the project's effectiveness will be submitted to EPA as an addendum when the data become available. A professionally produced video program about this project is hoped to be produced in 1996, to be used for outreach purposes, and will also be submitted to EPA upon completion.

If successful, this technology could be employed wherever acidic seep fronts can be accessed by surface trenching. All the major seep areas along the Red River between the Molycorp mill and the Questa Ranger Station potentially could be treated using this interim treatment method. In addition, isolated sources of acidic drainage such as tributary drainages from scar areas between town and the Molycorp Mill, as well as subchannel contributions from Bitter Creek, could also be treated in this fashion. Although desirable, anoxic alkaline drain treatment addresses symptoms rather than the causes of acid rock drainage. Given the magnitude and complexity of the causes of ARD discharge to the Red River, this may be the best short-term treatment while long-term remedial actions are considered.

Molycorp, in conjunction with their research staff at Unocal, has expressed interest in designing passive treatment systems for ARD from the waste rock piles in Capulin Canyon and Goathill Gulch. These systems will probably consist of anoxic alkaline drains and constructed composting wetlands, and would be constructed just below the present seepage collection systems so that inflow rates can be controlled.

4.3 RECOMMENDATIONS FOR BEST MANAGEMENT PRACTICES

The following BMPs have proven to be effective in reducing pollution from mineral extraction and processing sites.

4.3.1 STEADY-STATE ACID ROCK DRAINAGE

1. Sulfide reduction chambers - This technology involves collecting ARD and directing it into a sealed chamber filled with composted manure. The drainage works its way through the organic material from an inlet at the base of the chamber and issues from an outlet at the top. Sulfide reduction occurs through bacterial action within the chamber and effluent generally has reduced metals concentrations. Problems with this technology include a finite collection and treatment

capacity, freezing of inlet or outlet lines and a tendency to add sulphur to effluent at levels that can prove toxic to fish.

2. Anoxic Alkaline Drains - This passive treatment technology involves the interception of ARD in a sealed limestone-filled trench. The limestone (with high CaCo3 content) buffers the low pH, which facilitates the precipitation of metals. These systems often discharge into smaller retention basins where most metals precipitate out of solution, before the drainage flows into a constructed compost wetland for secondary treatment. Problems with these systems include an acute sensitivity to increased levels of dissolved oxygen that can lead to coating of the limestone with iron hydroxides, rendering it ineffective.

3. Wetlands - Over the past decade the use of wetlands to treat acid mine drainage (as well as municipal sewerage) has increased dramatically. This passive technology has proven to be a very cost effective alternative to standard chemical treatment. Bacterial activity in the wetland substrate and roots of emergent vegetation accomplishes most of the metal reduction in wetland treatment systems. Problems with this technology include damage to the system and release of metal-loaded drainage during peak runoff events. Also, many researchers in this area warn that a wetland treatment system can become overloaded with metal precipitates held in the organic substrate, and these are then subject to pulse releases in flood times and can become toxic to the emergent vegetation that hold the system together. Periodic clean-out of wetland treatment systems and subsequent reconstruction will almost certainly become a component of this passive treatment technology anywhere it is employed.

4. Source Control - Ultimately the most effective and permanent method of addressing ARD is to control its generation by remediating the source. By capping and sealing waste-rock piles and tailings piles, the supply of water and oxygen (both necessary to sustain the ARD process) can be eliminated or reduced. Similarly, by consolidating various sources into a single unit, total surface area available for oxidation and infiltration is reduced.

5. Other BMPs - Sodium hydroxide feeders and other expensive chemical treatment systems that require constant maintenance in perpetuity are not considered appropriate technologies for the treatment of acid rock drainage.

4.3.2 PULSE LOADING - SURFACE RUNOFF

1. Material Binders - In recent years products have been placed on the market that bind surface materials together in ore

stockpiles, waste dumps, or tailing facilities. Most of these products are sprayed as either a liquid emulsion or a fine grained solid on the surface of material piles. The effect of these products is to bind surface particulates together to form a shield against wind and water transport. Problems with this approach include the short duration of their effectiveness and uncertainty about potential toxic side effects.

2. Filter Strips - In many cases the installation of vegetative and or fabric filter strips can greatly reduce the pulse loading impact from minesites, at least for a while. Mines and mills have often been developed in narrow canyons or montaine environments, where they commonly disposed of their wastes in piles adjacent to or in stream channels. This configuration set up two basic stream degrading situations that persist and often worsen over the years. First, the linear placement of wastes along stream channels truncates drainage patterns upslope of the piles, setting up the classic condition that results in ARD. Secondly, the outslope of waste piles being at or near the angle of repose maximizes the volume of waste that is transported to the stream channel in pulse events. The re-establishment of a stable riparian community in a strip along the outslope of waste piles in conjunction with a fabric filter fence during the first season or two of growth could greatly reduce the general sediment load from such piles. It is likely, however, that the benefits from actions of this sort would be short term unless the offending piles were subsequently stabilized. Problems with BMPs involving filter strips include the likelihood of phyto-toxic response to sediments and leachate in areas in need of vegetative treatment, and the short duration of effectiveness when used as the sole BMP at a given site.

3. Complete site reclamation - The only known effective long-term means to eliminate contaminant transport from mining sites is to carry out complete site reclamation. Complete reclamation is a series of connected processes designed to restore damaged natural system components. These processes include returning a site to a stable drainage configuration by reconstructing truncated drainage channels and establishing reasonable slopes between drains before developing a suitable growth medium on the slopes to facilitate the return of stable native vegetative communities. The use of temporary diversions and slope terracing is often necessary to achieve the desired end. The result is a stable and self-sustaining natural ecosystem. Most of the problems associated with complete reclamation are tied to the high cost of implementing such BMPs. The will and the necessary budget required to maintain and repair failed reclamation components can also become problematic.

4.4 COSTS OF BMP IMPLEMENTATION

Any accurate estimate of costs associated with BMP implementation for a specific site is difficult without a detailed analysis of the area in question. With that in mind the following range of estimated costs are provided for general planning purposes.

Steady-state acid rock drainage:

1. Sulfide reduction chambers - The size of the chamber depends on the volume of drainage and other site specific conditions. The estimated range of costs for construction and maintenance is $6,000 - $30,000 per system.

2. Constructed Wetlands - Site conditions and the availability of onsite construction materials will affect costs. The estimated range of costs for construction and maintenance is $2,000 - $15,000 per acre of constructed wetland.

3. Anoxic Alkaline Drains - Again site conditions and size of the installation will greatly affect the estimated range of costs: $5,000 - $250,000 per system.

Pulse Loading - Stormwater Runoff:

1. Material Binders - The difficulty of mobilizing to a site and applying material binders will affect the estimated range of costs: $600 - $2,000 per acre of area treated.

2. Filter strips - $5 - $20 per linear foot of installed filter strip.

3. Complete Site Reclamation - Obviously site accessibility and conditions will have a significant effect on costs. The estimated range of costs for complete site reclamation is $10,000 - $65,000 per acre. If remediation of contaminated aquifers is involved as part of the complete site reclamation the costs can increase exponentially.

If the anoxic drain demonstrations prove the feasibility for application of this passive treatment technology at sites in the Red River watershed it is conceivable that a series of large systems could be employed to treat acid rock drainage that has impacted the middle reach of the Red River.

The prospects for success in controlling pulse loading from the small sites above Molycorp are good if adequate funding and support for this effort can be generated. The Molycorp site with its massive waste piles, open pit, miles of roads, and tailings ponds will remain a challenge for the foreseeable future.

V. SUMMARY

The Red River Groundwater Investigation was a two-year project funded by USEPA under a CWA Section 319(h) grant to NMED. The objective of this project was to determine groundwater quality and aquifer characteristics along the impaired reaches of the Red River in order to identify, and ultimately eliminate, impairment of both the aquifer and the designated uses of the river. Following an initial literature review and evaluation of existing data, a period of extensive field work ensued to document, monitor, and sample at areas of concern. After reviewing point source discharges and sources of contamination for stormwater runoff that could impact the Red River, the investigation focused on nonpoint sources of contamination that impact the river through seepage inflow of contaminated groundwater.

For most of its length, the Red River has been shown to be a gaining stream; groundwater recharge contributes to the flow of the main stem throughout most of the reach from the upper valley above the Town of Red River to the confluence with the Rio Grande. A progressive downstream deterioration of water quality has been documented, from pristine headwaters originating in alpine wilderness, past the Town of Red River, to the biologically impoverished reach of approximately eight miles between the Molycorp mine and the Village of Questa. Water quality degradation in this reach is illustrated by increasing downstream concentrations of total dissolved solids, sulfate, and metals.

A number of groundwater-related nonpoint sources of pollution to Red River were identified and investigated, and are listed here in order of their significance:

1. Mining-related sources of acid rock drainage, or ARD (Molycorp mine and mill, and the old abandoned hard rock mining sites located on several tributaries to Red River)

2. Scar areas and debris flows that generate ARD (naturally occurring hydrothermal alteration erosional scars).

3. Septic tank leachfields and liquid waste holding tanks in subdivisions of the upper Red River valley.

4. Unlined sewage lagoons for the Village of Questa.

5. Sites of former leaking underground storage tanks (USTs) in the Town of Red River.

Of the sources listed above, by far the greatest impact is the steady-state seepage of ARD in the form of dozens of acidic metal-loaded seeps or springs. The ARD is from two principal sources: mining wastes or disturbed areas, and the hydrothermal alteration scars. A few of the old mine sites located on Red River tributaries exhibit ARD but these sources are insignificant compared to the massive disturbances of Molycorp mine and the approximately twenty scar areas in the watershed. The scar areas are known to generate ARD and therefore have an impact on local groundwater and surface water resources. Because some scars are located upgradient of Molycorp mine, and underlay some of the mine features, the problem of attributing relative contributions of ARD from Molycorp wastes and the scar areas becomes complex. Sources of ARD from the mine include high-sulfide material in the waste-rock dumps, open pit, underground workings, and relic tailings deposits near the mill. The principal areas of seepage to the river occur at Cabin Springs, Portal Spring, and the mouth of Capulin Canyon. Geochemical studies indicate that the acid generation process within mine waste sources is relatively immature and is likely to worsen in the future and continue for an indefinite period. Water quality of seeps and springs impacted by ARD may further deteriorate.

In 1994 a series of twelve new groundwater monitoring wells were installed by Molycorp along the middle reach of the Red River. These were the first monitoring wells to be installed in the area of the mine and various waste sources (fourteen other wells have been previously installed by Molycorp in the tailings area below Questa). There are two principal, and interconnected, groundwater systems in the mine area - a fractured bedrock aquifer and an overlying aquifer within the alluvium and valley-fill of the Red River and tributary drainages. The new monitoring wells have provided hydrogeologic information and water quality data for both systems. The various seeps have also been sampled; most are located in alluvium but some discharge from bedrock. Water from all the new mine monitoring wells, as well as the seeps in the middle reach of the Red River, exceed NM Groundwater Standards for certain constituents (TDS, sulfate, Fl, Al, Fe, Mn, Co, Cu, Ni, Zn, Cd). For both aquifers there is evidence for a release of these contaminants from Molycorp sources. Data show that water from mine wastes contains significantly greater concentrations of sulfate and metals (Al, Be, Mn, Zn, Cu, Cd) than water from scar areas. In comparing water quality of seeps located downgradient of Molycorp to seeps located at scars upgradient of the mine, a more than three-fold increase is shown for concentrations of Be, Al, Cu, and Mn. Data for the fractured bedrock aquifer indicates a release of As, Cd, and Cu that is partially attributable to Molycorp mine.

Analysis of data from USGS groundwater seepage investigations in 1965 and 1988 indicates that there was a significant (149%) increase in seepage rates (groundwater accretion) to the middle reach of the Red River near Molycorp in 1988 as compared to 1965. The Molycorp open pit was begun in 1965; by the time of the 1988 seepage investigation the pit had been in place for more than twenty years. The pit and associated waste-rock dumps enhance groundwater recharge and may be responsible for the documented increase in seepage rates, and changes in water quality.

station), High Country Rentals (former Chevron Red River station), Resort Realty (former Conoco station). Two of these seven sites (Chevron and Diamond Shamrock, as mentioned above) have confirmed releases and are under investigation or remediation. At the other sites no hydrocarbon contamination has been detected in any of the soil samples collected from borings, and no groundwater samples have shown hydrocarbon contamination above regulatory action levels. At present there is no known impact to the Red River from these sites.

The greatest need for action at any of the nonpoint pollution sources that have been described above is in dealing with the seepage of acid rock drainage from Molycorp mine sources and scar areas, and in controlling releases from liquid waste systems in the developments of the upper Red River valley. Efforts to address some of these problems have begun. A 319(h) workplan has been written to address stabilization and sediment control of scar areas in the Bitter Creek watershed (94-B), and the Liquid Waste Program continues to grapple with the septic tank problems. Although agencies and municipalities continue to be involved in this process, the best hope for effective long term solutions to water quality problems in the Red River watershed lies with a concerned citizenry and an active Red River-Questa Watershed Association.

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LIST OF FIGURES

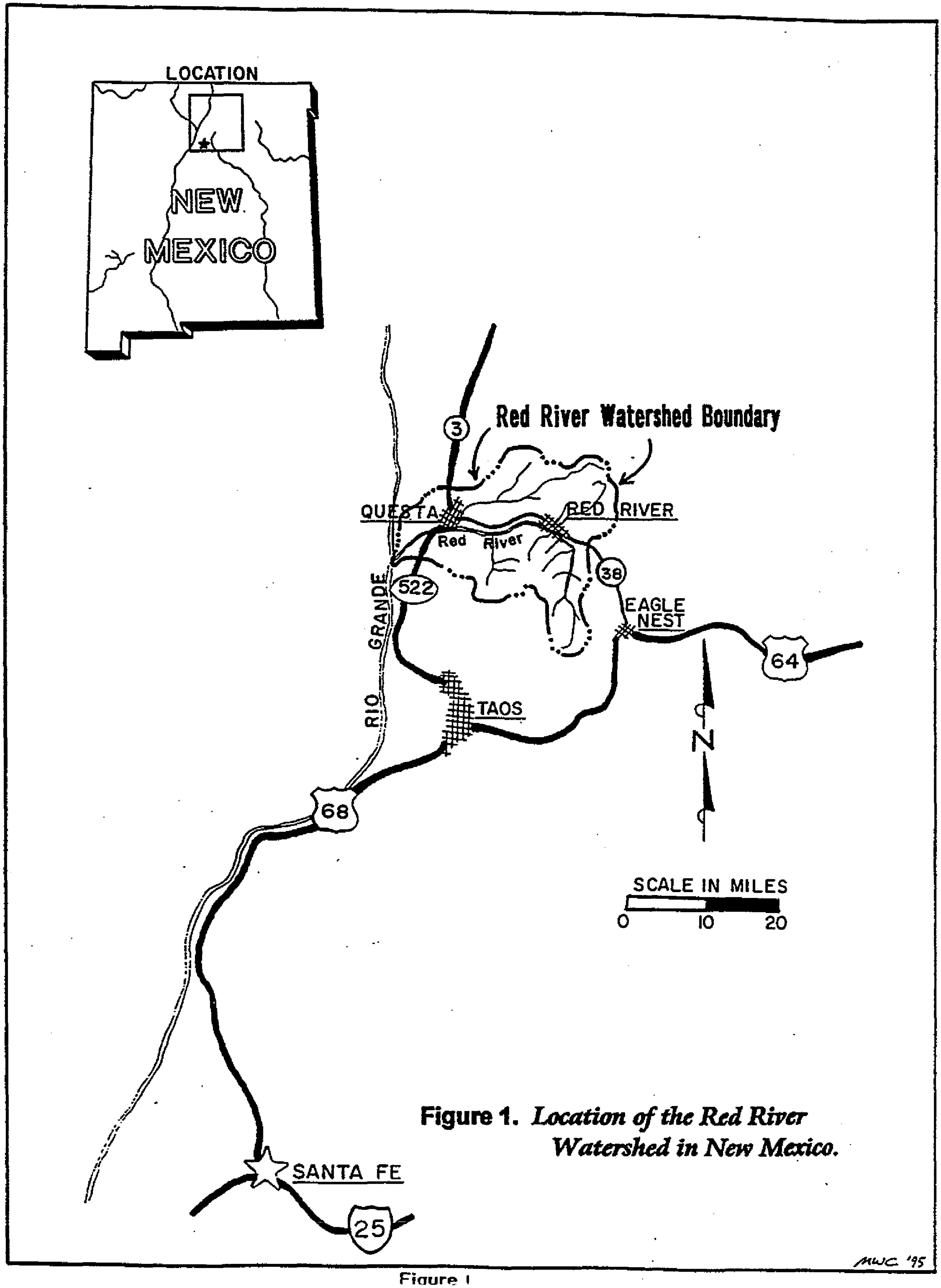


Figure 1. *Location of the Red River Watershed in New Mexico.*

Figure I

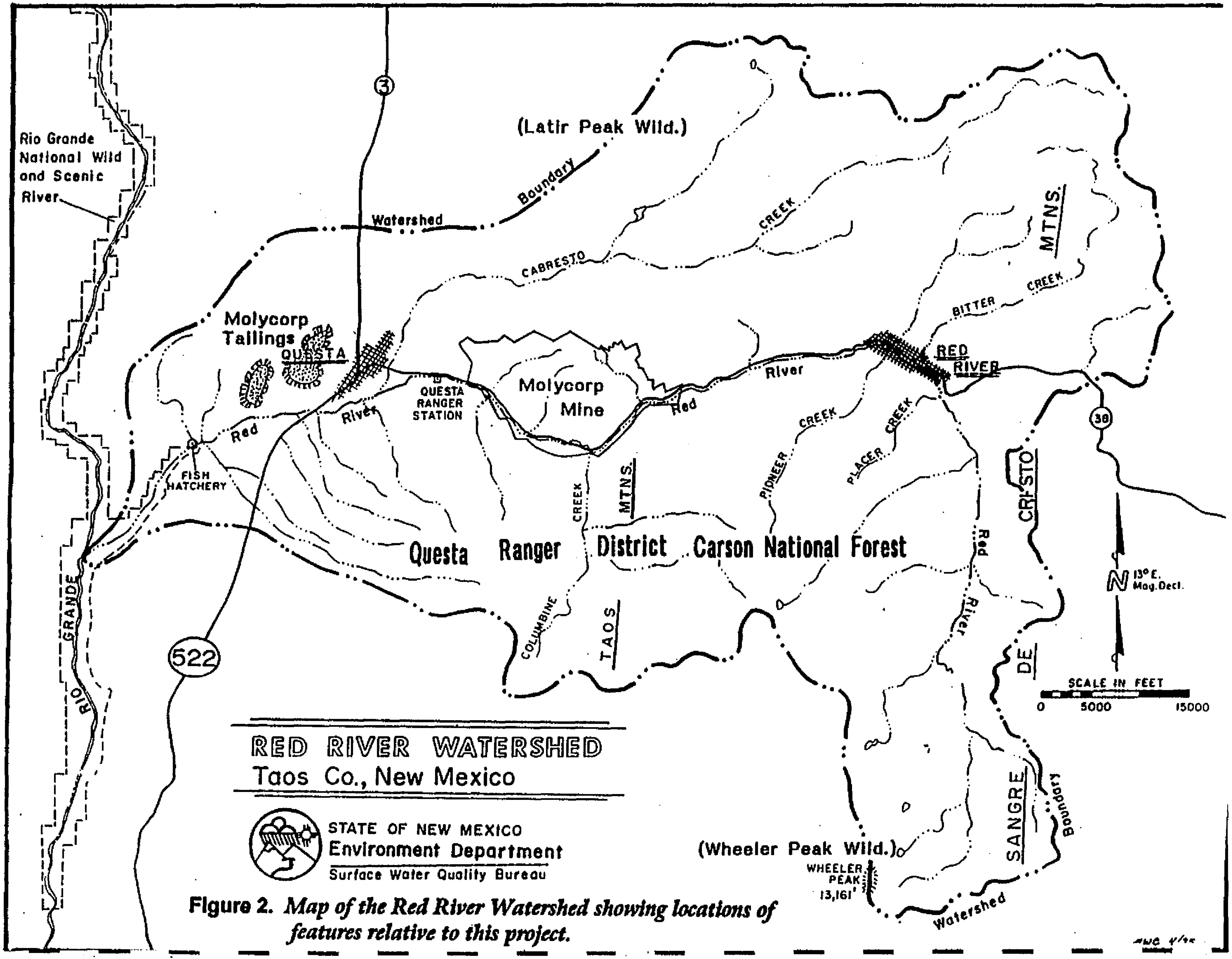


Figure 2. *Map of the Red River Watershed showing locations of features relative to this project.*

FIGURE 2.

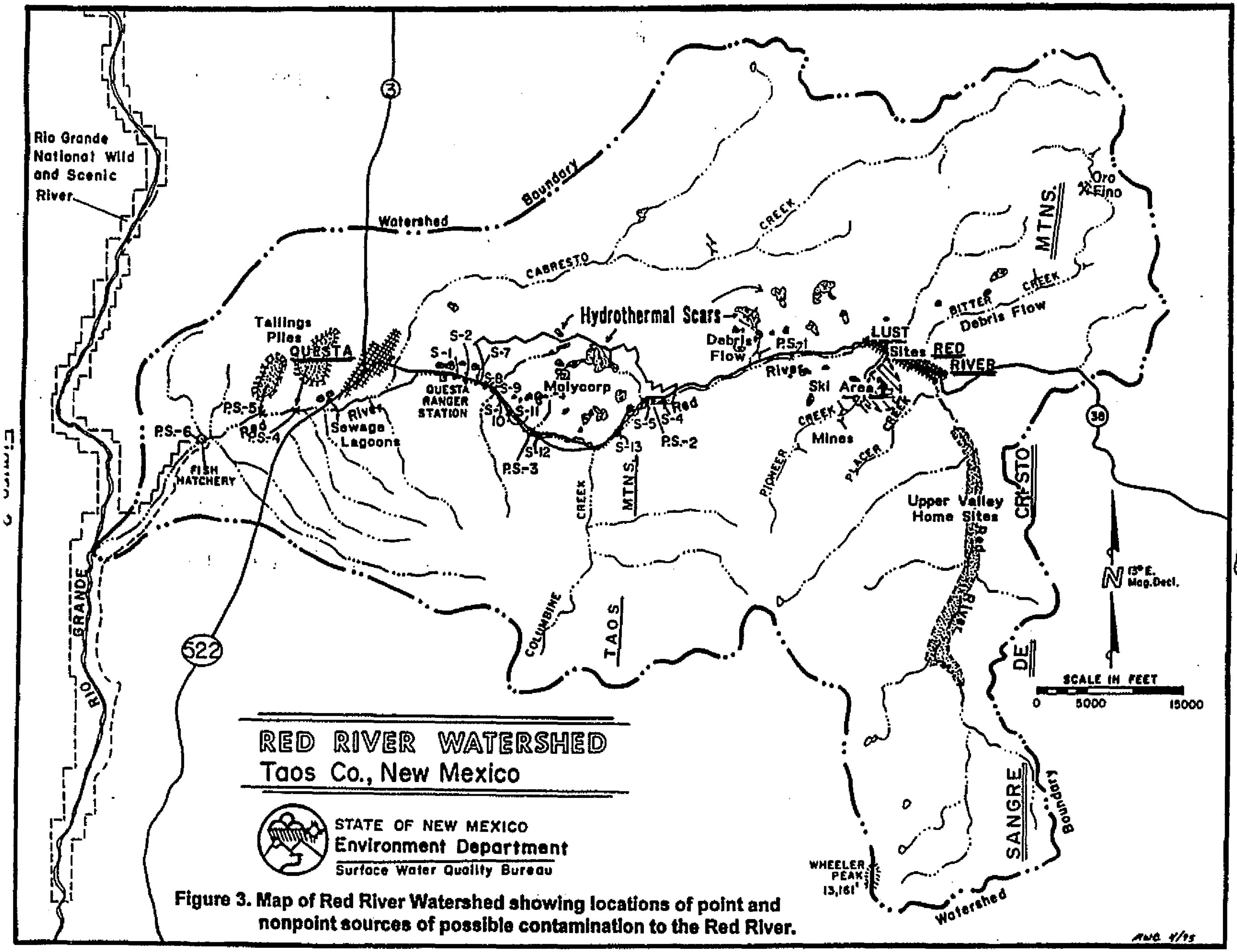


Figure 3. Map of Red River Watershed showing locations of point and nonpoint sources of possible contamination to the Red River.

Figure 3.

EXPLANATION

POINT SOURCE POLLUTION:

PS-1: Town of Red River Wastewater Treatment Plant

PS-2: Molycorp Mill Site Outfall #005

PS-3: Molycorp Mine, Goathill Gulch Outfall #004

PS-4: Molycorp East Tailings Pile Outfall #002

PS-5: Molycorp Pope Lake/W.Tailings Outfall #001

PS-6: Red River Fish Hatchery (NMDG&F)

NONPOINT SOURCE POLLUTION:

S-1 to S-13: Red River Groundwater Seeps (ARD)

Hydrothermally Altered Volcanic Rock Scars

Molycorp Mine

Scattered Abandoned Mine and Mill Sites (Esp. Pioneer and Bitter Creeks)

Upper RR Valley Home Sites: septic tanks, leach fields

Town of Red River: Leaking Underground Storage Tanks (LUST)

Red River Ski Area

Town of Questa Sewage Lagoons

Landslide/ Debris Flow Gravels and Sediment (Bitter, Hansen and Hotentot Creeks)

Figure 4.

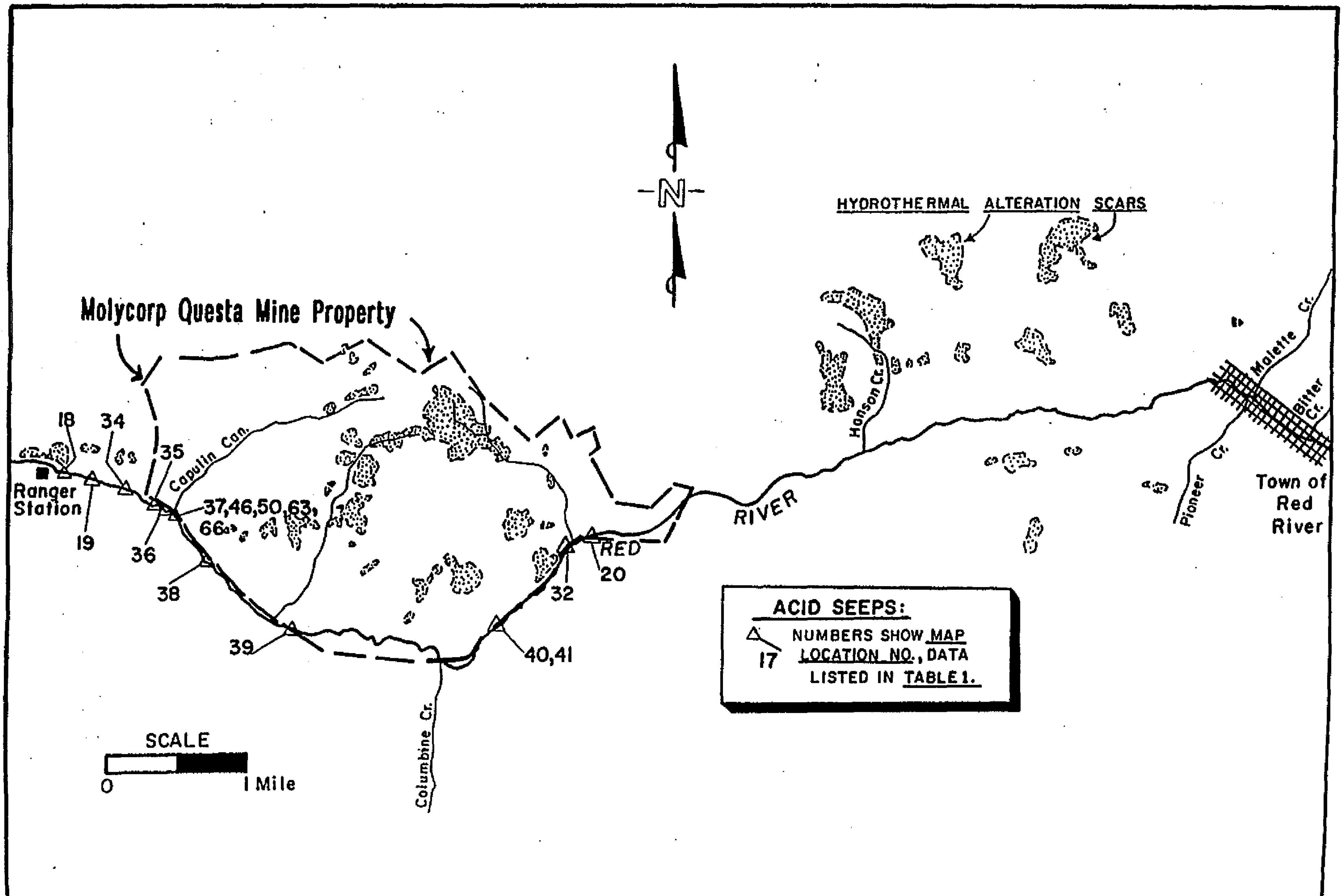
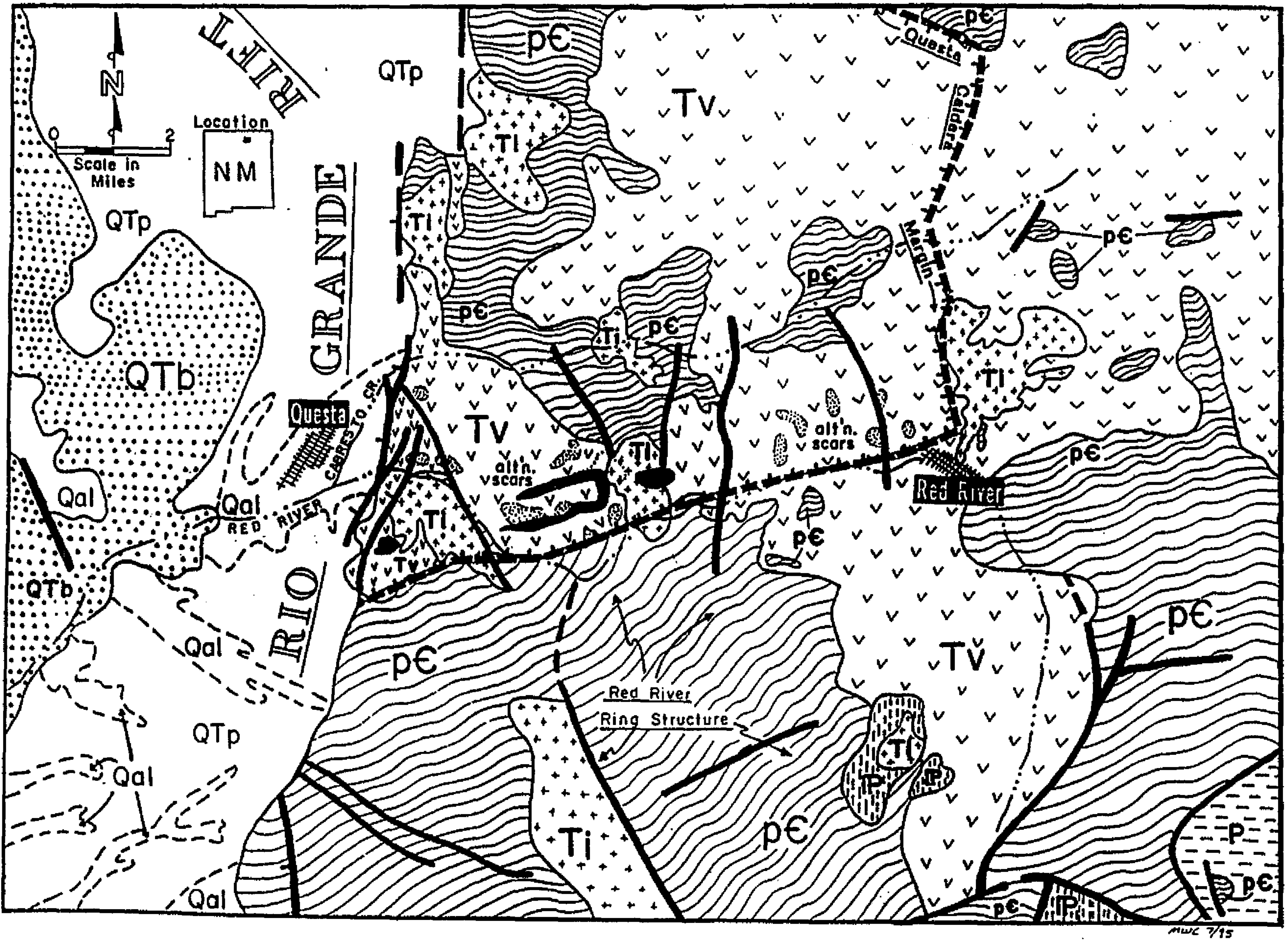


Figure 4. *Map of the middle reach of the Red River showing the Molycorp Questa Mine, acid seeps and natural hydrothermal scar areas.*



EPA / NMED RED RIVER WATERSHED PROJECT 319(h) Grant (92-A)

Figure 6. Composite Geologic Map of Red River-Questa Area.

Explanation

Qal -- Quaternary Alluvium
Qtb -- Quat./Tertiary Basalt
Qtp -- Q/T Pediment Fill
Ti -- Tertiary Intrusives
Tv -- Tert. Volcanic and Igneous Rocks
P -- Permian Sediments
IP -- Pennsylvanian Rocks
pC -- Precambrian Basement

Symbols

Faults
Hydrothermal Alteration Scars
Molybdenum Mineralization

Sources of Geologic Information:
-Dane and Bachman, 1965, Geologic Map of New Mexico; USGS/NM BM&MR.
-McKinlay, 1957, Geology of Questa Quad., NMBM&MR.
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Figure 6A.

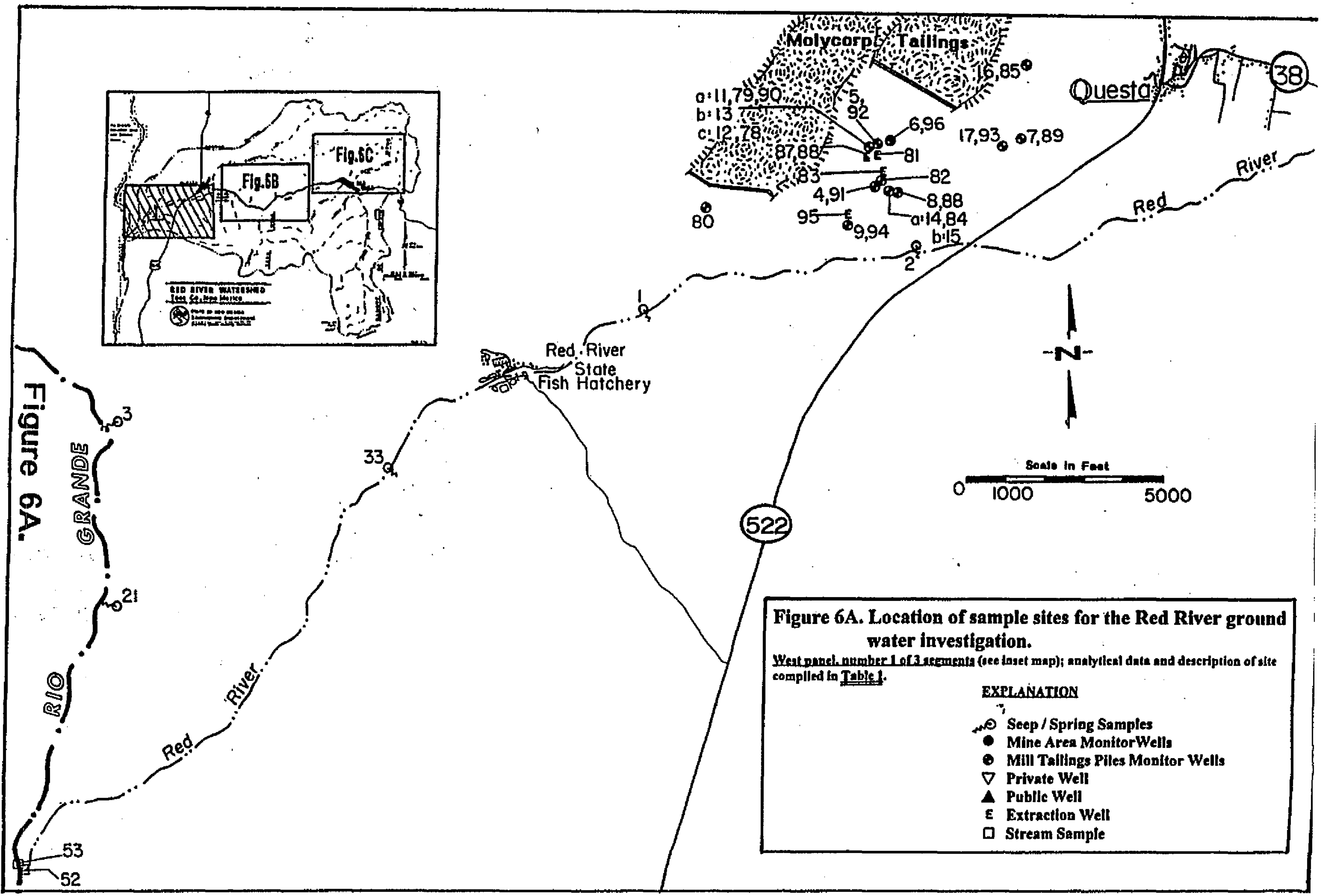


Figure 6A. Location of sample sites for the Red River ground water investigation.

West panel, number 1 of 3 segments (see inset map); analytical data and description of site compiled in Table 1.

Figure 6B.

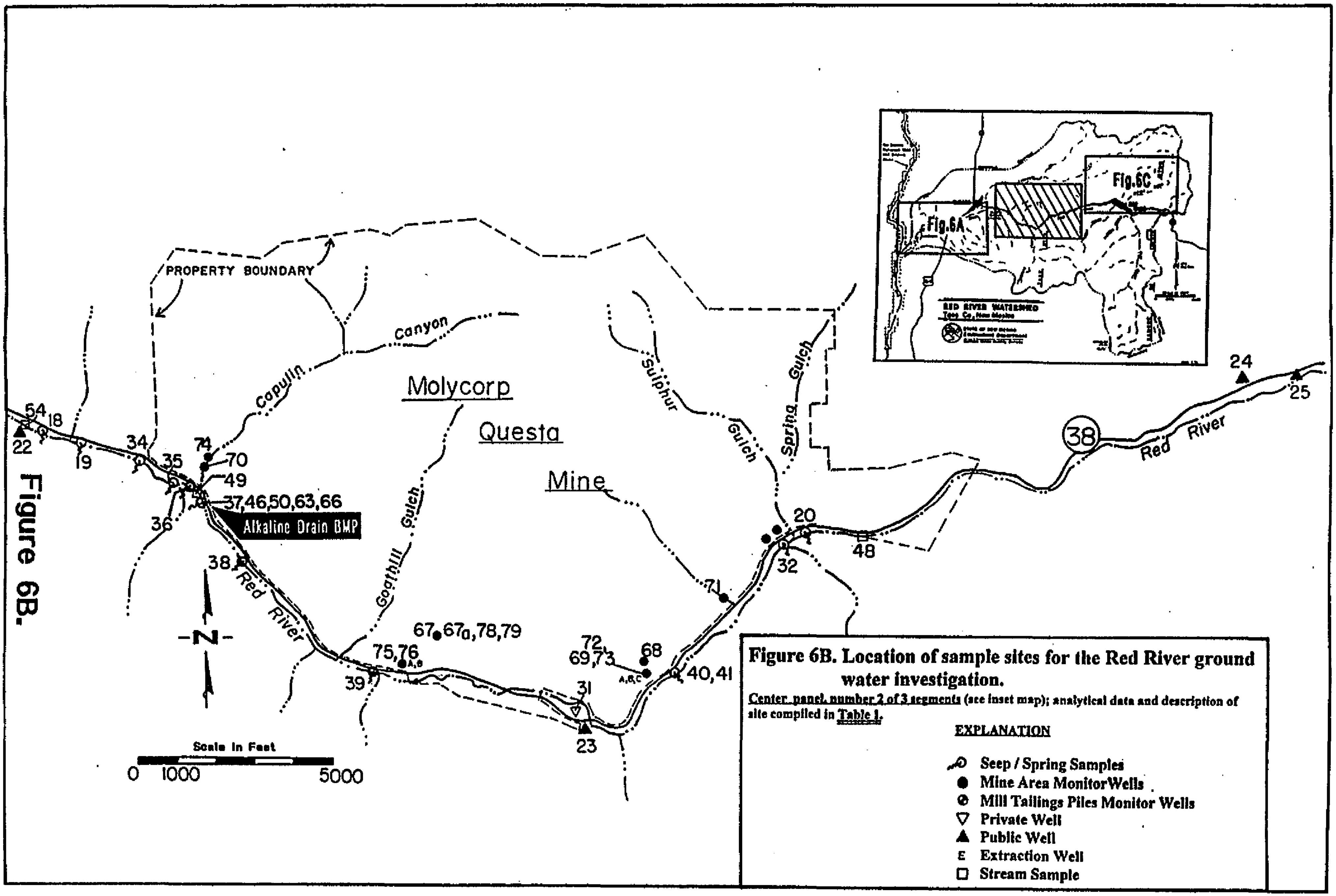


Figure 6B. Location of sample sites for the Red River ground water investigation.

Center panel, number 2 of 3 segments (see inset map); analytical data and description of site compiled in Table 1.

EXPLANATION

- ⊘ Seep / Spring Samples
- ● Mine Area MonitorWells
- ⊘ Mill Tailings Piles Monitor Wells
- ▽ Private Well
- ▲ Public Well
- ε Extraction Well
- ☐ Stream Sample

Figure 6C.

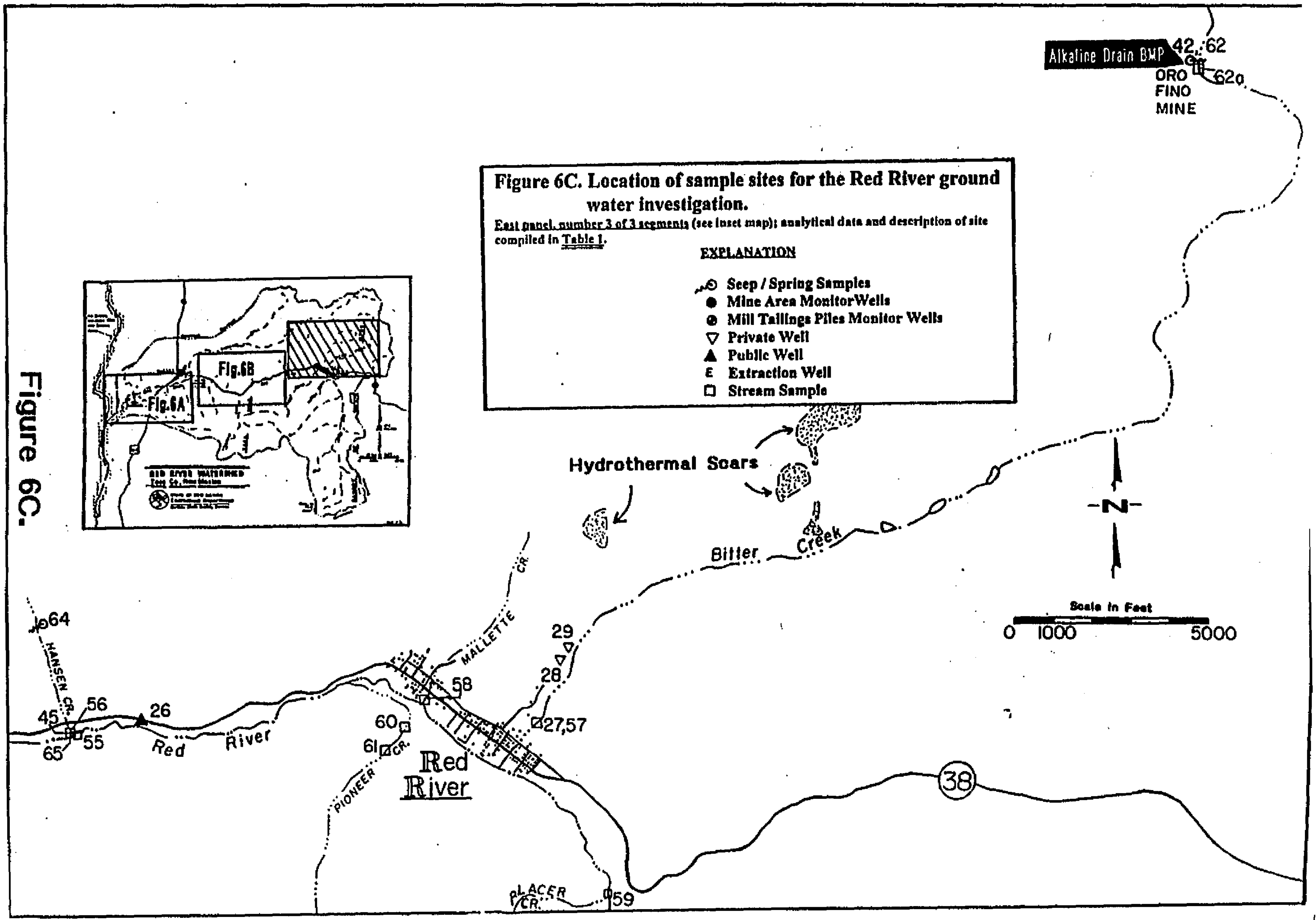


Figure 6C. Location of sample sites for the Red River ground water investigation.

East panel, number 3 of 3 segments (see inset map); analytical data and description of site compiled in Table 1.

EXPLANATION

- Seep / Spring Samples
- ● Mine Area MonitorWells
- Mill Tailings Piles Monitor Wells
- ▽ Private Well
- ▲ Public Well
- Ɛ Extraction Well
- ☐ Stream Sample

Figure 7.

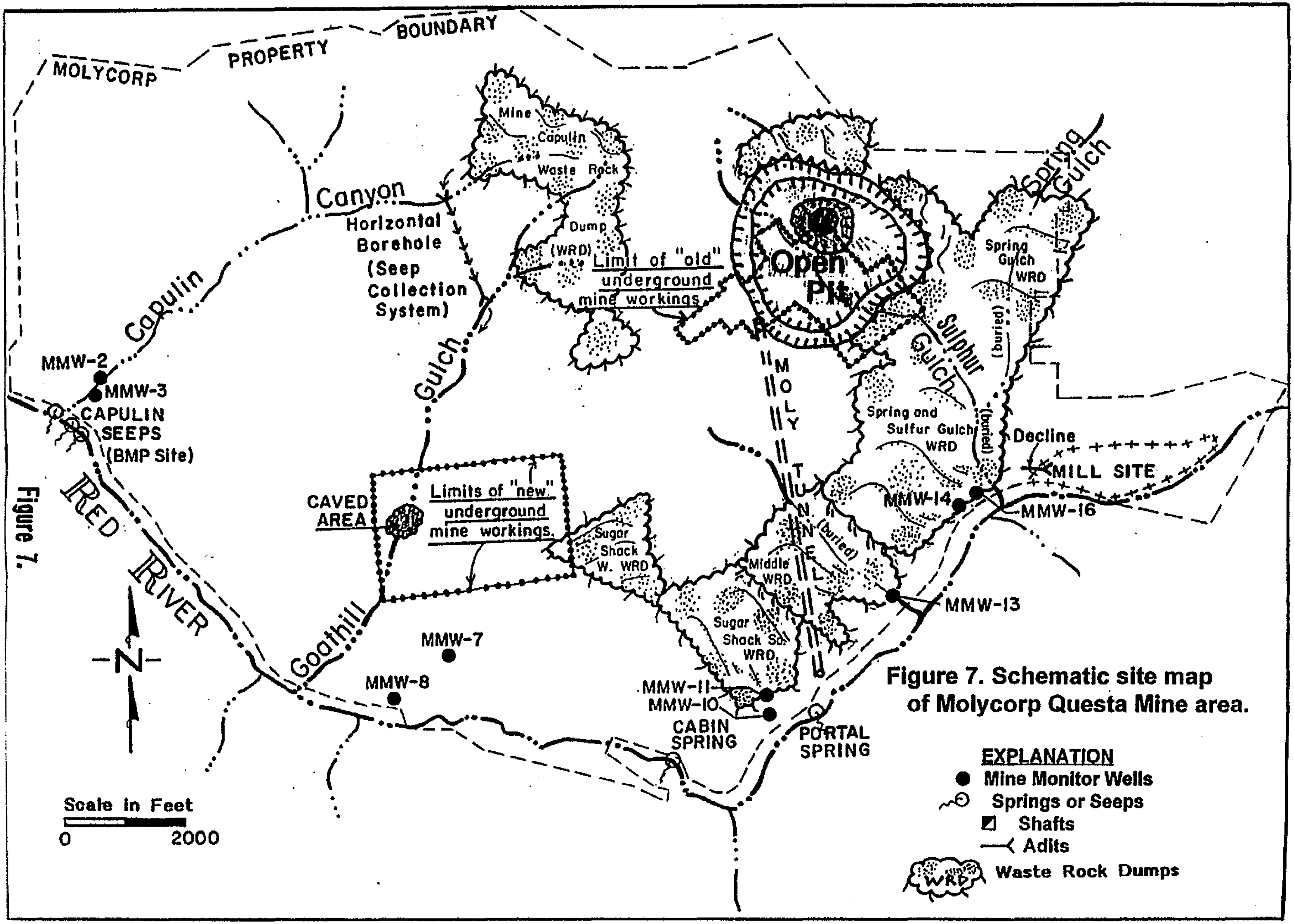


Figure 7. Schematic site map of Molycorp Questa Mine area.

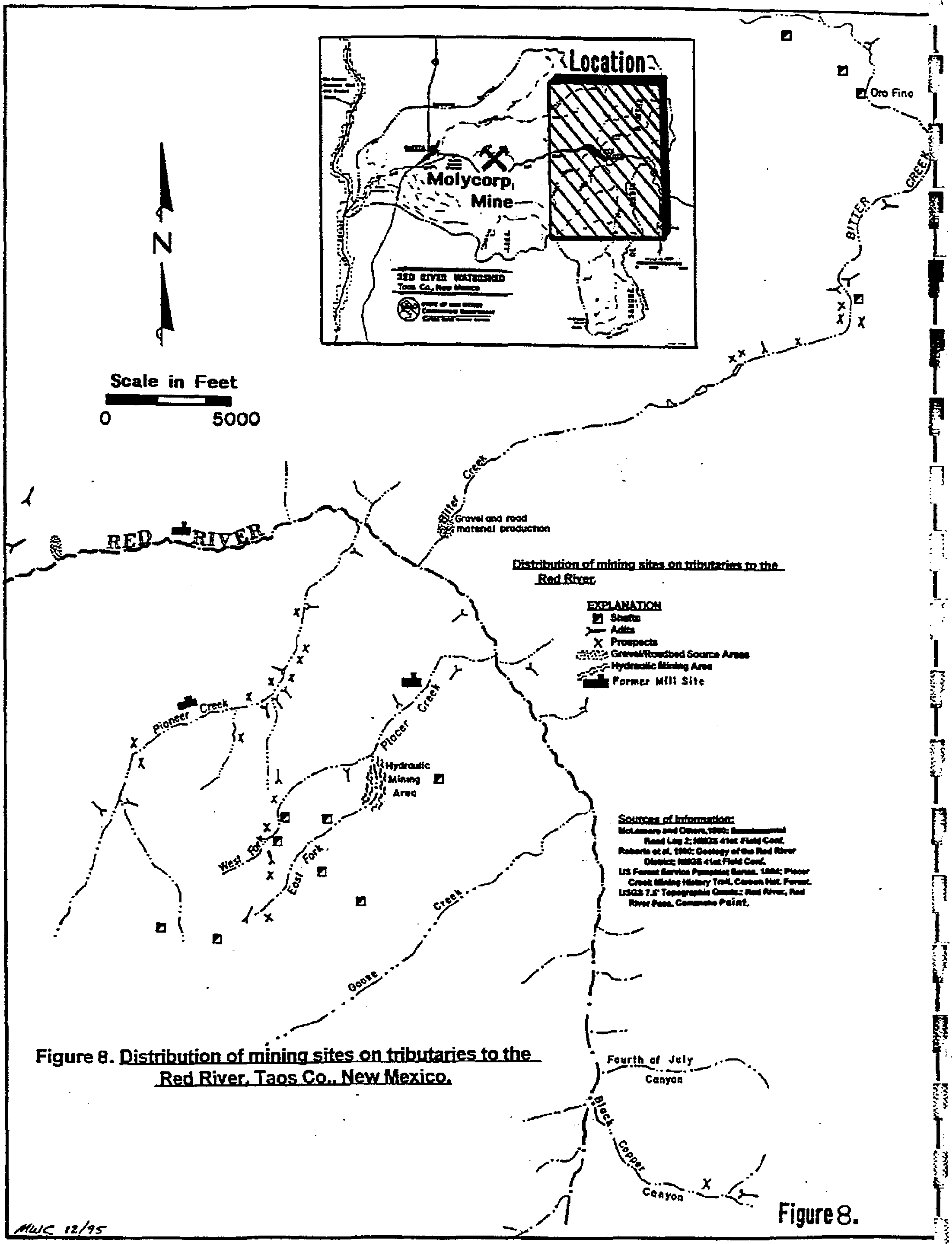
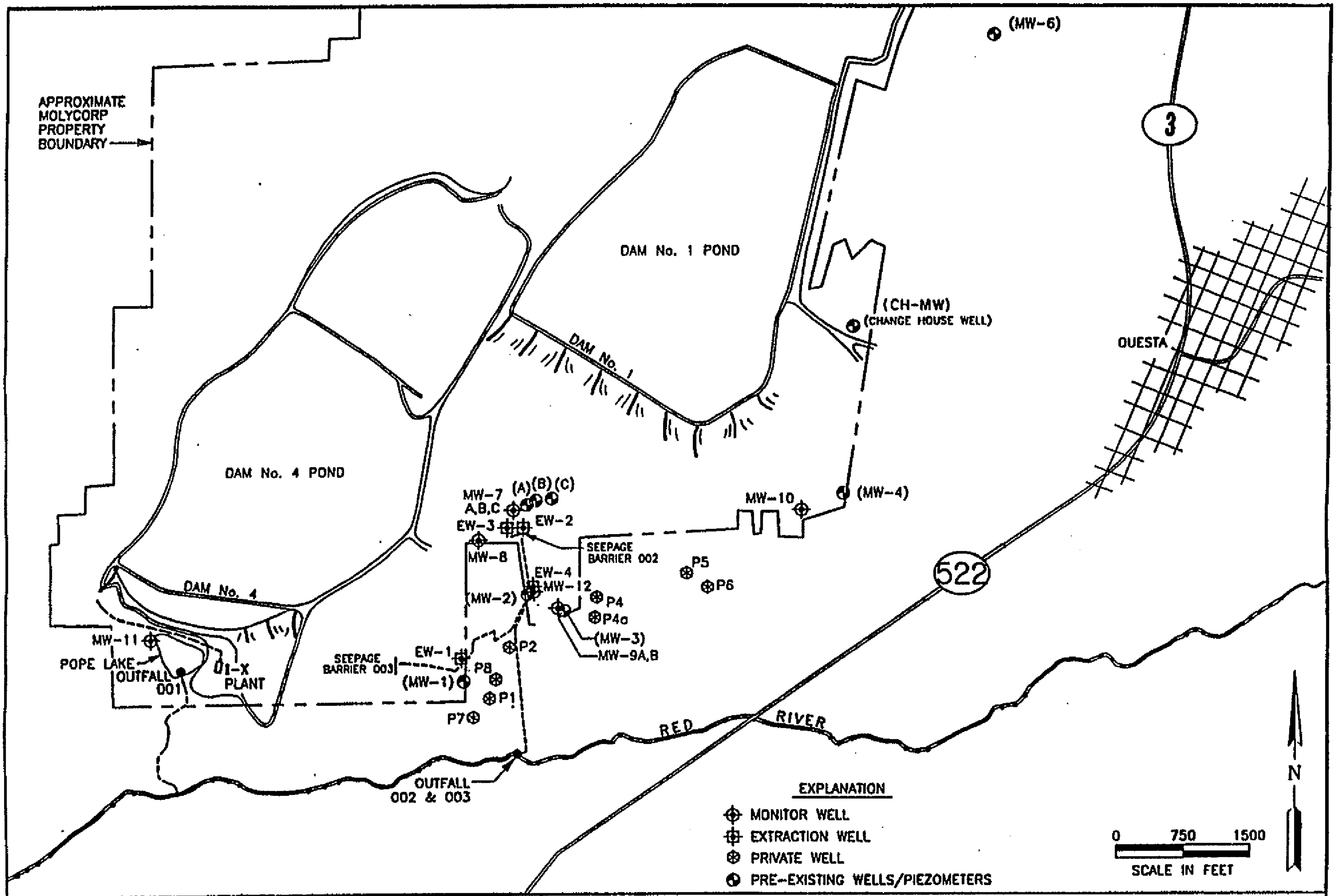


Figure 8. Distribution of mining sites on tributaries to the Red River, Taos Co., New Mexico.

MWC 12/95

Figure 9.



EPA / NMED Red River Watershed Project (92-A)

Figure 9. Molycorp Questa Mine -- Tailings Area Site Map

(Modified after South Pass Resources report to Molycorp, Fig. 3, dated 2/10/95)

LIST OF TABLES

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp Area.
(Updated 3/18/96, mwc)

Sheet # 1 of 10.
Orig.File: RdRiv1.XLA

Map Location	1	2	3	4	5	6	7	8	9	10
Station	Hatchery (Cold)	Hatchery (Warm)	B. Arsenic Spring	MW-2	MW-A	MW-C	MW-4	MW-3	MW-1	MW-11
				(Samples from wells monitoring MolyCorp tailings)						
North Latitude										
West Longitude										
Date Sampled	8/12/93	8/12/93	8/12/93	8/17/93	8/17/93	8/17/93	8/17/93	8/17/93	8/17/93	8/17/93
Sample Type	Spring-gw	Spring-gw	Spring-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw
	* Filtered or **Unfiltered Sample (Dissolved or Total Metals)									
Analyte (mg/L)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	**	**	**	*	*	*	*	*	*	*
Al	< 0.1	< 0.1	< 0.1		< 0.01		< 0.02	< 0.01	< 0.02	< 0.02
Cd	0.002	< 0.001	< 0.001	< 0.001	0.003	0.007	< 0.001	< 0.01	< 0.001	< 0.001
Co	< 0.05	< 0.05	< 0.05							
Cu	< 0.05	< 0.05	< 0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fe	< 0.1	0.1	< 0.1	0.09	0.07	0.16	< 0.05	< 0.05	< 0.05	< 0.05
Pb	< 0.005	< 0.005	< 0.005	< 0.001	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.005
Mn	< 0.05	< 0.05	< 0.05	**0.49**	0.03	**3.6**	< 0.01	< 0.01	0.04	< 0.01
Mo	0.01	< 0.05	< 0.01	**1.83**		**2.3**	0.25		0.052	0.11
Ni	< 0.1	< .1	< .1							
Zn	< 0.05	< 0.05	< 0.05	< 0.05		0.02	< 0.01		0.01	0.02
SO4				**870**	570	**1080**	515	**735**	510	89
Hardness										
FieldConduct.	355	290	210	1250	990	1510	920	1200	900	325
TDS	300	382	160			**1880**	**1003**	**1343**	**982**	268
Field pH	6.5	6.5		7.7	7.4	7.2	7.3	7.4	7.2	8.1
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm;Turbidity in NTU; pH in units;other analytes in mg/l.

Table 1. Water Analysis of Selected Analyses From Red River / MolyCorp Area.

Sheet # 2 of 10.
Orig.File: RdRiv2.XLA

Map Location	11	12	13	14	15	16	17	18	19	20
Station	MW-7a	MW-7c	MW-7b	MW-9a	MW-9b	Change House	MW-10	S-1	S-2	S-4
	(Wells monitoring tailings areas)									
North Latitude								36*42.15'	36*42.082'	
West Longitude								105*33.804	105*33.64'	
Date Sampled	8/18/93	8/18/93	8/18/93	8/18/93	8/18/93	8/18/93	8/18/93	8/24/93	8/24/93	8/24/93
Sample Type	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	Seep-gw	Seep-gw	Seep-gw
		***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**					
Analyte (mg/l)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	*	*	*	*	*	*	*	*	*	*
Al	< 0.02	0.01	< 0.02	< 0.02	0.02	< 0.02	**1.9**	**100.0**	**100.0**	0.6
Cd	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	**0.04**	**0.045**	0.002
Co								**0.27**	**0.3**	< 0.05
Cu	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	0.01	0.5	**0.86**	< 0.05
Fe	< 0.05	< 0.01	< 0.05	< 0.05	< 0.05	< 0.05	**0.69**	**0.6**	**0.8**	0.01
Pb	< 0.005	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	0.006	**< 0.10**	< 0.005
Mn	0.01	< 0.01	< 0.01	**1.3**	0.12	< 0.01	**0.09**	**44**	**44.0**	**0.28**
Mo	0.015		0.008	0.012		0.004	0.025	< 0.1	< 0.1	< 0.1
Ni								**0.08**	**0.7**	< 0.1
Zn	0.03		0.018	0.032		0.35	0.02	**9.3**	**8.8**	0.15
SO4	**625**		**710**	348	50	58	54	**1510**	**1090**	176
Hardness								693	471	291
Field Conduct.	690	1980	1150	740	230	382	240	1250	1190	355
TDS	**1146**		**1176**	752	183	286	192			374
Field pH	7.1	**10.6**	8.9	7.6	7	7.5	8.1	**3.9**	**4.1**	6.8
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 3 of 10.
Orig.File: RdRiv3.XLA

Map Location	21	22	23	24	25	26	27	28	29	30
Station	L. Arsenic Spring	Ranger Station	Columbine C.G.	Fawn Lakes C.G	Elephant Rock C.G.	Junebug C.G.	Bitter Creek	HarrisonWell (Bitter Ck.)	Davis Well (Bitter Ck.)	Mallette Rd. Seep (S-6)
North Latitude		36*42.19'	36*40.855'	36*42.342'	36*42.484'	36*42.54'	36*42.548'			
West Longitude		105*33.97'	105*30.901	105*27.33'	105*26.864	105*26.146'	105*23.955'			
Date Sampled	8/24/93	8/24/93	8/24/93	8/24/93	8/24/93	8/24/93	8/24/93	8/24/93	8/24/93	9/8/93
Sample Type	Spring-gw	P Well-gw	P Well-gw	P Well-gw	P Well-gw	P Well-gw	Spring-sw	P Well-gw	P Well-gw	Seep-gw
		*Filtered or **Unfiltered Sample (Dissolved or Total Metals)								
Analyte (mg/l)	F / UnF **	F / UnF **	F / UnF **	F / UnF **	F / UnF **	F / UnF **	F / UnF *	F / UnF **	F / UnF **	F / UnF *
Al	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	**9.9**	2.9	0.4
Cd	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	**0.011**	0.003	0.004
Co	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05
Cu	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.79	0.32	< 0.05
Fe	< 0.1	< 0.1	< 0.1	0.1	0.1	**0.7**	0.6	**1.6**	**1.7**	**5.1**
Pb	< 0.005	0.018	0.01	< 0.005	< 0.005	0.009	< 0.005	< 0.005	< 0.005	< 0.005
Mn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	**2.61**	**0.8**	**1.9**
Mo	< 0.1	< 0.1	< 0.1	< 0.1	< 1.0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Ni	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Zn	< 0.05	0.09	1.5	< 0.1	0.15	**8.6**	0.08	2.0	0.22	0.39
SO4	17	96	10	105	60	44	46.0	308	114	156
Hardness	82	152	80	152	135	121	82	259	86	148
FieldConduct.	193	215	120	230	160	175	155	420	195	220
TDS						150				298
Field pH	7.8	7.3	6.6	6.9	7.1	6.8	7.2	**4.9**	**4.6**	**5.3**
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 4 of 10.
Orig.File: RdRiv4.XLA

Map Location	31	32	33	34	35	36	37	38	39	40
Station	Fagerquist Motel	Sulfur Gulch(S-5)	.Red Riv Spring	Red Riv. Seep (S-7)	S-8 Seep Rd.Excav'n	S-9 Seep Rv.Channel	Red Riv. Seep (S-10)	Red Riv. Seep(S-11)	Red Riv. Seep(S-12)	Red Riv. Seep(S-13a)
North Latitude				36*42.145'	36*41.879'	36*41.862'	36*41.82'	36*41.627'	36*41.097'	36*41.092'
West Longitude				105*33.485	105*33.039	105*32.948'	105*32.943'	105*32.762	105*32.008'	105*30.512'
Date Sampled	9/9/93	9/9/93	9/10/93	9/21/93	9/21/93	9/21/93	9/21/93	9/21/93	9/21/93	2/3/94
Sample Type	Pr. Well-gw	Seep-gw	Spring-gw	Seep-gw	Seep-gw	Seep-gw	Seep-gw	Seep-gw	Seep-gw	Seep-gw
	***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**						
Analyte (mg/l)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	**	*	**	*	*	*	*	*	*	* / **
Al	< 0.1	1.2	0.1	**96.0**	**180.0**	**140.0**	**130.0**	**65.0**	**36.0**	**24 / 23**
Cd	0.001	0.004	< 0.001	0.039	**0.087**	**0.018**	**0.019**	**0.012**	**0.011**	**0.019 / 0.02**
Co	< 0.05	< 0.05	< 0.05	**0.27**	**0.72**	**0.25**	**0.22**	**0.11**	**0.12**	**0.07 / 0.07**
Cu	< 0.05	< 0.05	< 0.05	0.9	**2.0**	0.77	**1.3**	1.1	0.15	0.17 / 0.3
Fe	< 0.1	< 0.1	< 0.1	< 0.1	**2.1**	**7.3**	**29.0**	0.4	< 0.1	< 0.1 / 0.3
Pb	< 0.005	< 0.005	< 0.005	< 0.005	0.004	< 0.005	< 0.005	< 0.005	< 0.005	< .001 / .001
Mn	< 0.05	0.06	< 0.05	**42.0**	**110.0**	**21.0**	**20.0**	**10.0**	**4.4**	**13.0 / 12.0**
Mo	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1 / < 0 .1
Ni	< 0.1	< 0.1	< 0.1	**0.7**	**1.6**	**0.5**	**0.5**	**0.3**	**0.4**	**0.3 / 0.2**
Zn	< 0.05	0.41	< 0.05	8.7	**23.0**	4.7	4.1	2.7	1.5	1.38 / 1.5
SO4	9.0	344	19	**1200**	**2600**	**1800**	**1700**	**828**	**1400**	**914**
Hardness	68	351	68	533	1420	834	824	427	1160	768
Field Conduct.	104	500	195	1140	2450	1800	1670	850	1200	800
TDS	90	562	164	**2047**	**4580**	**3008**	**2797**	**1476**	**2400**	**1362**
Field pH	6.8	6.1	6.9	**4.2**	**3.9**	**3.3**	**3.6**	**4.5**	**4.9**	**4.9**
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards for gw (seep,spring,well) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 5 of 10.
Orig.File: RdRiv5.XLA

Map Location	41	42	43	44	45	46	47	48	49	50
Station	Seep (S13b)	Orofino Mn. treat.drain	U.Red Rive algal pool	Upper Red Riv.	Hansen Cr. at confluence	Seep (S10) abv. Capulin	UpperR.R. V.of Pines	R.R.upstr. of Moly. mill	R.R. blw. Capulin Cn.	Capulin at R.R. (S10)
North Latitude	36*41.092'				36*42.153'	36*41.82'				36*41.82'
West Longitude	105*30.512'				105*27.757'	105*32.943'				105*32.943'
Date Sampled	2/3/94	6/22/94	7/21/94	7/21/94	5/4/94	5/4/94	8/2/94	8/2/94	8/2/94	8/2/94
Sample Type	Seep-gw	Seep-gw	Stream-sw	Stream-sw	Seep-gw	Seep-gw	Stream-sw	Stream-sw	Stream-sw	Seep-gw
		***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**					
Analyte (mg/l)	F / UnF *	F / UnF * **	F / UnF **	F / UnF **	F / UnF **	F / UnF * **	F / UnF **	F / UnF **	F / UnF **	F / UnF **
Al	**13.0**	0.7 / 1.7			**86**	**120 / 130**		**1.8**	**4.4**	**120**
Cd	**0.014**	<.001/<.001			0.007	<0.1 / <0.1		< 0.001	< 0.001	**0.032**
Co	< 0.05	0.08 / 0.08			**0.15**	**.22 / .21**		< 0.05	< 0.05	**0.2**
Cu	0.09	0.01 / 0.01			0.12	**1.2 / 1.2**		0.01	0.03	**1.2**
Fe	< 0.01	**7.0 / 10.0**			**19.0**	**31.0 / 32.0**		**4.1**	**4.4**	**12.0**
Pb	0.002	<0.1 / <0.1			< 0.005	<0.1 / <0.1		0.016	0.011	0.007
Mn	**6.2**	**1.8 / 1.9**			**7.2**	**19.0 / 19.0**		0.19	**0.76**	**19.0**
Mo	< 0.1	<0.1 / <0.1			< 0.1	<0.1 / <0.1		< 0.1	< 0.1	< 0.1
Ni	**0.2**	0.1 / 0.2			**0.4**	**0.5 / 0.4**		< 0.1	< 0.1	**0.5**
Zn	1.1	0.08 / 0.06			2.3	**5.0 / 4.6**		0.03	0.14	4.3
SO4	**743**	647						68	123	**1532**
Hardness	705	766						123	163	799
FieldConduct.	750	1100	335	150	1700	1600	105	220	290	1500
TDS	**1134**	**1028**	106	234				196	238	**2302**
Field pH	**5.3**	6.6	7.0	7.0	**3.1**	**3.5**	7.0	6.9	**5.9**	**4.0**
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 6 of 10.
Orig.File: RdRiv6.XLA

Map Location	51	52	53	54	55	56	57	58	59	60
Station	Rio Grande at Pilar	RR at RGnd confluence	RG at RR confluence	RR at Questa RS	RR at Hansen Cr.	Hansen Cr. at RR confl.	Bitter Cr. above RR	Mouth of MalletteCr.	R.R. at Placer Ck.	Pioneer Cr. blw.Ski area
North Latitude				36*42.188'	36*42.153'	36*42.154'	36*42.548'	36*42.575'	36*41.709'	36*42.58'
West Longitude				105*34.108'	105*27.757	105*27.756'	105*23.955	105*24.603	105*23.56'	105*24.706'
Date Sampled	8/3/94	8/31/94	8/31/94	8/31/94	8/31/94	8/31/94	8/31/94	8/31/94	8/31/94	8/31/94
Sample Type	Stream-sw	Stream-sw	Stream-sw	Stream-sw	Stream-sw	Stream-sw	Stream-sw	Stream-sw	Stream-sw	Stream-sw
	***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**						
Analyte (mg/l)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	* **	**	**	**	**	**	**	**	**	**
Al	0.2 / 11.0		0.2	16	1.3	340.0	360.0	38.0	0.8	4.8
Cd	<.001/ <.001		< 0.001	0.003	< 0.001	0.013	0.026	0.001	< 0.001	< 0.001
Co	<.05 / <.05		< 0.05	<0.05	< 0.05	0.4	0.21	<0.05	< 0.05	< 0.05
Cu	<.01 / 0.04		< 0.01	0.22	0.03	0.66	9.4	0.3	< 0.01	0.04
Fe	0.4 / 38.0		0.3	53.0	3.8	1300.0	1200.0	69.0	0.9	13.0
Pb	.002 / 0.1		< 0.002	0.062	0.008	2.3	1.6	0.3	0.001	0.029
Mn	<.05 / 0.39		< 0.05	1.5	0.16	32.0	13.0	1.1	< 0.05	0.32
Mo	<.10 / <.10		< 0.1	<0.1	< 0.1	< 0.1	0.6	<0.1	< 0.1	< 0.1
Ni	<.10 / <.10		< 0.1	< 0.1	< 0.1	0.9	0.6	<0.1	< 0.1	< 0.1
Zn	0.04 / 0.11		< 0.1	0.4	0.04	3	1.5	0.5	< 0.1	0.04
SO4	84	119	30	143				43	13	29
Hardness	133	154	96	173				41	94	84
FieldConduct.	320	270	195	260	178	1200	850	72	125	110
TDS	262	244	186	270				172	112	136
Field pH	6.9	7.0	7	6.4	6.4	4.2	3.4	7.2	6.2	7.2
Turbidity/r=rain	>1000(r)	265	4.96	>1000(r)	35.7	>1000(r)	>1000(r)	>1000	18.4	293(r)

Bold numeric values exceed NM WQCC standards for gw (seep, spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 7 of 10.
Orig.File: RdRiv7.XLA

Map Location	61	62	62a	63	64	65	66	67	67a	68
Station	Pioneer Cr. abv.Ski area	Oro Fino ARD	B.Cr. at the OroFinoMn	Capulin Cn. Seep	Hansen Cr. scar drain.	Hansen Cr. at Hwy.	Capulin Cn. mouth	MMW-7 @ 61.1'	MMW-7 duplicate	MMW-11 @ 89.5'
North Latitude	36*42.303'									
West Longitude	105*24.92'									
Date Sampled	8/31/94	7/24/92	7/24/92	7/8/92	7/8/92	7/7/92	2/21/95	11/7/94	11/7/94	
Sample Type	Stream-sw	Seep-gw	Seep-gw	Seep-gw	Seep-gw	Stream-sw	Seep-gw	M Well-gw	M Well-gw	M Well-gw
			***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**				
Analyte (mg/l)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	**	* **	*	* **	* **	* **	* **	*	*	*
Al	1.5	**89 / 95**	0.27	**130 / 140**	**88 / 89**	110 / 120	**150 / 120**	**950**	**890**	**54**
Cd	< 0.001	.005 / .005	<0.001	**.028 / .029**	.004 / .003	.008 / .006	**.021 / .025**	**0.11**	**0.11**	**0.04**
Co	< 0.05	**0.52 / 0.54**	<0.05	**0.22 / 0.22**	.11 / .11	0.2 / 0.21	**.23 / .20**	**4.3**	**3.9**	**0.25**
Cu	< 0.01	0.29 / 0.32	<0.05	**1.3 / 1.3**	.05 / <.05	.156 / .152	**1.5 / 1.4**	**4.5**	**4.5**	**0.9**
Fe	3.0	**990 / 1050**	0.3	**20.0 / 21.0**	**36 / 45**	7.3 / 7.5	**20.0 / 24.0**	**420**	**380**	<0.1
Pb	0.007	<.005/<.005	<0.005	<.005/<.005	<.005/<.005	<.005/<.005	<.005 / .007	**1.0**	**0.8**	<0.01
Mn	0.1	**4.2 / 4.2**	<0.05	**18.6 / 19.1**	**5.08 / 5.32**	10.9 / 11.11	**19.0 / 18.0**	**69**	**72**	**28**
Mo	< 0.01	**2.4 / 2,8**	<0.1	<0.1 / <0.1	<0.1 / <0.1	<0.1 / <0.1	<0.1 / <0.1	<0.1	<0.1	<0.1
Ni	< 0.01	**1.5 / 1.6**	<0.1	0.5 / 0.5	**0.3 / 0.3**	0.5 / 0.5	**0.5 / 0.4**	**9.5**	**8.6**	**0.6**
Zn	0.01	1.5 / 1.4	<0.05	4.7 / 4.8	2.3 / 2.5	3.33 / 3.33	4.9 / 4.2	**9.7**	**9.8**	**4.6**
SO4	25		<5.0				**1490**	**9366**	**9066**	**1287**
Hardness	84		50				839	6097	6039	1004
FieldConduct.	109						1400	7100	7100	1490
TDS	130		78				**2,232**	**15,258**	**16,524**	**2,124**
Field pH	7.2						**4.0**	**4.4**	**4.4**	**5.6**
Turbidity	**88.5**		1.33							

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 8 of 10.
Orig.File: RdRiv8.XLA

Map Location	69	70	71	72	73	74	75	76	77	78
Station	MMW-10B	MMW-3	MMW-13	MMW-10A	MMW-10C	MMW-2	MMW-8B	MMW-8A	Dupl.MW-3	MW-7C
(Depth to water)	@ 21.6'	@ 29.6'	@ 109.1'	@ 21.7'	@ 21.8	@ 33.7'	@ 96.0'	@ 96.8'	@ 20.4'	@ 116.2'
North Latitude										
West Longitude										
Date Sampled	11/7/94	11/7/94	11/8/94	11/8/94	11/8/94	11/8/94	11/8/94	11/8/94	11/8/94	11/9/94
Sample Type	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw
			***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**				
Analyte (mg/l)	F / UnF *	F / UnF *	F / UnF *	F / UnF *	F / UnF *	F / UnF *	F / UnF *	F / UnF *	F / UnF *	F / UnF *
Al	**7.6**	1.0	<0.1	**33**	**31**	**68**	0.2	0.4	<0.1	0.4
Cd	**0.02**	0.003	<0.001	**0.03**	**0.025**	**0.02**	<0.002	<0.005	<0.002	<0.002
Co	**0.08**	**0.07**	0.011	**0.14**	**0.1**	**0.33**	0.003	0.003	<0.002	<0.002
Cu	**0.2**	<0.1	<0.01	0.5	0.4	<0.1	<0.02	<0.01	<0.02	<0.02
Fe	0.07	0.1	0.2	<0.1	<0.1	**61**	**3**	<0.1	0.08	0.1
Pb	0.03	<0.1	<0.001	<0.01	<0.01	<0.01	<0.002	<0.001	<0.002	<0.002
Mn	**8.5**	**33**	**0.91**	**15**	**16**	**53**	**7.8**	**0.23**	0.05	<0.002
Mo	<0.01	<0.01	0.051	<0.01	<0.01	<0.01	0.01	<0.001	0.004	0.009
Ni	**0.3**	**0.2**	<0.1	**0.3**	**0.3**	**0.7**	<0.1	<0.1	<0.1	<0.1
Zn	1.4	1.3	0.2	2.1	2.9	**10**	<0.02	0.2	<0.02	<0.02
SO4	**1080**	**1759**	**717**	**1030**	**849**	**2177**	**1279**	**716**	**729**	**754**
Hardness	1193	1708	847	952	795		1440	686	738	858
FieldConduct.	2050	2050	1050	1210	1020	3139	2276	1326	1463	1538
TDS	**1882**	**3070**	**1442**	**1882**	**1690**	**3524**	**2292**	**1282**	**1400**	**1360**
Field pH	7.5	7.5	7.9	**5.9**	**4.7**	7.3	**8.1**	6.0	7.3	7.2
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards
for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private,
P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in
NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet # 9 of 10.
Orig.File: RdRivr9.XLA

Map Location	79	80	81	82	83	84	85	86	87	88
Station	Duplicate o	MW-11	EW-2	MW-12	EW-4	MW-9A	ChangeHouse	Outfall 002	EW-3	MW-3
	MW- 7A	@ 194.4'	@ 150.6'	@ 129.7	@ 21'	@ 29.1'	CH-MW		@ 60.2'	@ 20.4'
North Latitude	(at 61.6')									
West Longitude										
Date Sampled	11/9/94	11/9/94	11/9/94	11/9/94	11/8/94	11/8/94	11/8/94	11/4/94	11/8/94	11/9/94
Sample Type	M Well-gw	M Well-gw	E Well	M Well-gw	E Well-gw	M Well-gw	M Well-gw	NPDES-sw	E Well-gw	M Well-gw
	***Filtered or **Unfiltered Sample**			**(Dissolved or Total Metals)**						
Analyte (mg/l)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	*	*	*	*	*	*	*	*	*	*
Al	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.06	<0.01	<0.02
Cd	<0.002	<0.001	<0.002	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001
Co	<0.002	<0.001	<0.002	<0.001	<0.001	<0.01	<0.001	0.003	0.001	0.001
Cu	<0.02		<0.02	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01
Fe	0.1	<0.05	<0.05	<0.05	<0.05	0.2	<0.1	<0.1	<0.1	0.1
Pb	<0.002	<0.001	<0.002	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001
Mn	0.002	0.003	0.15	0.002	0.005	0.17	0.006	1.9	0.07	0.06
Mo	0.009	0.067	0.007	0.012	0.003	<0.01	0.003	2.3	0.001	0.004
Ni	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zn	<0.02	<0.01	<0.02	<0.01	<0.01	<0.1	0.9	<0.01	<0.01	<0.01
SO4	**755**	52	85	61	139	**703**	65	896	418	**728**
Hardness	829	126	194	165	281	670	157	958	534	759
FieldConduct.	1422	315	431	282	560	1460	504		1032	1544
TDS	**1336**	243	283	296	480	**1318**	382	2124	898	**1432**
Field pH	7.5	7.0	7.5	**8.4**	7.7	6.4	**8.6**		7.5	7.3
Turbidity/r=rain										

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 1. Water Analysis of Selected Analytes From Red River / MolyCorp. Area

Sheet #10 of 10.
Orig.File: RdRivr10.XLA

Map Location	89	90	91	92	93	94	95	96
Station	MW-4	MW-7A	MW-2	MW-A	MW-10	MW-1	EW-1	MW-C
	@ 41.6'	@ 61.6'	@ 22.9'	@ 32.6'	@ 28.5'	@ 54.0'	@ 83.0'	@ 3.1'
North Latitude								
West Longitude								
Date Sampled	11/18/94	11/18/94	11/17/94	11/17/94	11/8/94	11/7/94	11/7/94	11/7/94
Sample Type	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	M Well-gw	E Well-gw	M Well-gw
		*Filtered or **Unfiltered Sample			(Dissolved or Total Metals)			
Analyte (mg/l)	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF	F / UnF
	*	*	*	*	*	*	*	*
Al	<0.01	<0.01	<0.04	<0.04	<0.01	<0.04	<0.1	<0.1
Cd	<0.001	<0.001	<0.004	<0.004	<0.001	<0.004	<0.002	<0.004
Co	<0.001	0.001	<0.004	<0.004	<0.001	<0.004	<0.002	<0.004
Cu	<0.01	<0.01	<0.04	<0.04	<0.01	<0.04	<0.02	<0.04
Fe	<0.1	<0.1	**5.4**	0.4	<0.1	0.2	<0.1	<0.1
Pb	<0.001	<0.001	<0.004	<0.004	<0.001	<0.004	<0.002	0.004
Mn	0.004	<0.001	**0.38**	0.037	<0.001	0.02	0.02	**0.88**
Mo	0.21	0.002	**1.7**	0.6	0.004	0.047	0.02	**1.2**
Ni	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zn	<0.01	<0.01	<0.04	<0.04	<0.01	<0.04	<0.02	<0.04
SO4	413	**720**	**819**	528	32	565	**603**	**896**
Hardness	444	772	730	638	87	606	715	917
FieldConduct.	1090	1422	1525		230	1238	1348	1786
TDS	878	**1278**	**1374**	**1036**	198	**1066**	**1140**	**1608**
Field pH	7.0	7.5	7.0	8.0	7.2	6.2	7.7	7.8
Turbidity/r=rain								

Bold numeric values exceed NM WQCC standards for gw (seep,spring,wells) or sw (stream) samples.

Wells: M=monitor, Pr=private, P=public, E=extraction.

Conductivity in umhos/cm; Turbidity in NTU; pH in units; other analytes in mg/l.

Table 2

Molycorp - Ground-Water Sample Analyses (mg/L except as noted) Page 1

Constituent	EW1	EW2	EW3	EW4	MW1	MW2	MW3	MW4	MW7A
Ca	192	55.6	152	76.4	172.4	213.2	215.2	120.4	231.2
Mg	57.1	13.4	37.4	21.9	42.6	47.9	53.9	34.8	47.2
K	6	6	5	4	6	6	4	4	6
Na	39	21	29	16	53	93	69	64	39
Hardness	715	194	534	281	606	730	759.5	444	772
Alkalinity	144	118	108	148	133	80	146	138	116
HCO3	176	144	132	180	162	98	178	168	142
CO3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Cl	18	<5	12	21	10	10	13	<5	12
Fl	0.3	0.5	0.2	0.2	0.3	1	0.5	0.7	0.2
SO4	603	85	418	139	565	814	728	413	720
NO3	0.7	0.2	0.6	0.4	0.6	<0.1	0.3	0.3	0.3
Cond. (uS/cm)	1348	431	1032	560	1238	1525	1544	1090	1422
pH (pH units)	7.7	7.54	7.54	7.72	6.23	6.99	7.34	7.01	7.51
TSS	<3	3	<3	<3	<3	8	<3	<3	<3
TDS	1140	283	898	480	1066	1374	1432	878	1278
ion sum	1003	253	719	367	930	1233	1171	720	1126
ion balance (%)	0.41	8.80	3.45	-0.41	-0.61	-0.15	-0.51	1.66	-1.17
total depth (ft.)	157	214	104	58	117	80	52	102	146
screen intvl. (ft.	83-157	104-185	62-77	42-58					
Sample Date	11/07/94	11/09/94	11/08/94	11/08/94	11/07/94	11/07/94	11/08/94	11/08/94	11/08/94
SLD # (ions)	wc946413	wc946437	wc946422	wc946430	wc946412	wc946416	wc946420	wc946418	wc946417
SLD # (NO3)	wc946381	wc946406	wc946391	wc946399	wc946380	wc946384	wc946389	wc946387	wc946386

Table 2

Molycorp - Ground-Water Sample Analyses (mg/L except as noted)   Page 2

Constituent	MW7C	MW7D	MW9A	MW10	MW11	MW12	MWA	MWC	CH
Ca	249.2	238	195	24.4	26.8	42	166	277.6	42.8
Mg	57.1	56.9	44.3	6.3	14.3	14.6	54.2	54.2	12.2
K	6	6	5	3	5	5	6	6	4
Na	45	44	71	14	27	27	50	78	61
Hardness	858	829	670	87	126	165	638	917	157
Alkalinity	118	118	96	72	76	121.4	150	158	197
HCO3	144	143	118	88	93	146.9	184	194	235
CO3	<3	0	<3	<3	<3	<3	<3	3	4
Cl	11	12	13	<5	7	<5	11	14	<5
Fl	0.2	0.2	0.5	0.5	1.3	0.4	0.4	1.2	0.8
SO4	754	755	703	32	52	61	528	896	65
NO3	0.3	0.3	0.6	0.3	0.4	0.3	0.4	<0.1	0.5
Cond. (uS/cm)	1538	1544	1460	230	315	282	na	1786	504
pH (pH units)	7.23	6.92	6.38	7.18	7.02	8.4	8.07	7.79	8.58
TSS	3	10	3	<3	<3	<3	8	<3	<3
TDS	1360	1336	1318	198	243	296	1036	1608	382
ion sum	1194	1183	1090	124	180	223	906	1425	306
ion balance (%)	2.27	0.54	-1.16	6.40	14.78	10.85	2.46	-0.84	5.88
total depth (ft.)	146		147	136(?)	249	234	38	15	250
screen intvl. (ft.						203-234			
Sample Date	11/09/94	11/09/94	11/08/94	11/08/94	11/09/94	11/08/94	11/07/94	11/07/94	11/08/94
SLD # (ions)	wc946435	wc946436	wc946429	wc946421	wc946434	wc946432	wc946415	wc946414	wc946423
SLD # (NO3)	wc946404	wc946405	wc946398	wc946390	wc946403	wc946401	wc946383	wc946382	wc946397

Table 2

Molycorp - Ground-Water Sample Analyses (mg/L except as noted) Page 3

Constituent	MW23	002	MMW2	MMW3	MMW8A	MMW8B	MMW10A	MMW10B	MMW10C
Ca	213.2	279.6	na	498	184.4	407	231.6	321	192.8
Mg	49.8	63	na	112	54.7	102.6	90.7	95.1	76.1
K	5	8	28	10	5	7	14	7	12
Na	73	97	81	103	33	41	32	26	25
Hardness	738	958	na	1708	686	1440	952	1193	795
Alkalinity	136	156	<3	209	10	154	<3	18	<3
HCO3	166	190	<3	255	13	187	<3	22	<3
CO3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Cl	13	11	<5	<5	<5	5	21	22	15
Fl	0.5	2.1	28	2.8	1.9	2.6	8.3	13.2	17.8
SO4	729	896	2177	1759	716	1279	1030	1080	849
NO3	0.4	0.1	<0.1	<0.1	0.8	<0.1	6.5	3	4.6
Cond. (uS/cm)	1463	1875	3139	2723	1326	2276	1823	3057	1563
pH (pH units)	7.27	6.86	3.86	7.63	5.99	8.07	4.41	6.19	4.53
TSS	5	<3	28	5	<3	7	<3	33	<3
TDS	1400	2124	3524	3070	1282	2292	1882	1882	1690
ion sum	1166	1450	2314	2610	1002	1936	1434	1578	1192
ion balance (%)	-0.70	3.23	-82.89	-2.52	0.29	1.45	-4.01	3.01	-3.23
total depth (ft.)			68	145	161	129	144	189	50
screen intvl. (ft.			38-58	65-115	125-161	67-117	79-130	133-189	31.5-50
Sample Date	11/08/94	11/04/94	11/08/94	11/07/94	11/08/94	11/08/94	11/08/94	11/07/94	11/08/94
SLD # (ions)	wc946433	wc946439	wc946438	wc946427	wc946419	wc946431	wc946425	wc946428	wc946424
SLD # (NO3)	wc946402	wc946385	wc946407	wc946395	wc946388	wc946400	wc946393	wc946396	wc946392

Table 2

Molycorp - Ground-Water Sample Analyses (mg/L except as noted)   Page 4

Constituent	MMW11	MMW13
Ca	229	258
Mg	104.5	48.9
K	20	7
Na	34	32
Hardness	1004	847
Alkalinity	156	146
HCO3	190	178
CO3	<3	<3
Cl	36	13
Fl	21	1.8
SO4	1267	717
NO3	6.2	2.6
Cond. (uS/cm)	1985	1478
pH (pH units)	4.43	6.59
TSS	<3	3
TDS	2124	1442
ion sum	1811	1168
ion balance (%)	-16.87	0.19
total depth (ft.)	185	148
screen intvl. (ft.	145-185	105-148
Sample Date	11/07/94	11/08/94
SLD # (ions)	wc946440	wc946426
SLD # (NO3)	wc946408	wc946394

Table 2
page 5

MOLYCORP
Ground Water Sample Analyses
NMED - Ground Water Section
November 4 - 9, 1994
(data reported in mg/L except as noted)

	EW1	EW2	EW3	EW3dup	EW4	MW1	MW2	MW3	MW4	MW7A	MW7Adup	MW7C	MW9A	MW10	MW11	MW12
Ca	192	55.6	152	213.2	76.4	172.4	213	215.2	120.4	231.2	238	249.2	195	24.4	26.8	42
Mg	57.1	13.4	37.4	49.8	21.9	42.6	47.9	53.9	34.8	47.2	56.9	57.1	44.3	6.3	14.3	14.6
Na	39	21	29	73	16	53	93	69	64	39	44	45	71	14	27	27
HCO3	176	144	132	166	180	162	98	178	168	142	143	144	118	88	93	146.9
CO3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	0	<3	<3	<3	<3	<3
Cl	18	<5	12	13	21	10	10	13	<5	12	12	11	13	<5	7	<5
SO4	603	85	418	729	139	565	814	728	413	720	755	754	703	32	52	61
NO3	0.7	0.2	0.6	0.4	0.4	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.6	0.3	0.4	0.3
Fl	0.3	0.5	0.2	0.5	0.2	0.3	1	0.5	0.7	0.2	0.2	0.2	0.5	0.5	1.3	0.4
K	6	6	5	5	4	6	6	4	4	6	6	6	5	3	5	5
Hardness	715	194	534	738	281	606	730	759.5	444	772	829	858	670	87	126	165
Alkalinity	144	118	108	136	148	133	80	146	138	116	118	118	96	72	76	121.4
Cond. (uS/cm)	1348	431	1032	1463	560	1238	1525	1544	1090	1422	1544	1538	1460	230	315	282
pH (pH units)	7.7	7.54	7.54	7.27	7.72	6.23	6.99	7.34	7.01	7.51	6.92	7.23	6.38	7.18	7.02	8.4
TSS	<3	3	<3	5	<3	<3	8	<3	<3	<3	10	3	3	<3	<3	<3
TDS	1140	283	898	1400	480	1066	1374	1432	878	1278	1336	1360	1318	198	243	296
Ion sum	998	246	714	893194	363	923	1226	1167	715	1120	1177	1187	1085	120	173	217
Ion balance (%)	0.41	8.80	3.45	3.45	-0.41	-0.61	-0.26	-0.51	1.66	-1.17	0.54	2.27	-1.16	6.40	14.78	10.85
Al	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					<0.1	<0.1	<0.1	<0.10
Sb	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001					<0.01	<0.001	<0.001	<0.001
As	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	0.003	0.002
Ba	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Be	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Bo	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cd	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Ca	240	61	170	310	100	200	260	300	160.00	310.00	320.00	280.00	300	28	30	51
Cr	<0.002	<0.002	<0.001	0.003	<0.001	<0.004	<0.004	0.008	<0.001	0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Co	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Cu	<0.02	<0.02	<0.01	<0.02	<0.01	<0.04	<0.04	<0.01	<0.01	<0.01	<0.02	<0.02	<0.1	<0.01	<0.01	<0.01
Fe	<0.1	<0.05	<0.1	<0.1	<0.05	0.2	5.4	0.1	<0.1	<0.1	0.10	0.06	0.2	<0.1	<0.05	<0.05
Pb	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Hg	<.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Mg	49	9.3	30	58	18	40	56	53	33.00	49.00	60.00	49.00	46	4.3	8	8.3
Mn	0.02	0.15	0.07	0.05	0.005	0.02	0.38	0.06	0.004	<0.001	<0.002	<0.002	0.17	<0.001	0.003	0.002
Mo	0.02	0.007	0.001	0.004	0.003	0.047	1.7	0.004	0.21	0.002	0.009	0.009	<0.01	0.004	0.067	0.012
Ni	<0.02	<0.02	<0.01	<0.02	<0.01	<0.04	<0.04	<0.01	<0.01	<0.01	<0.02	<0.02	<0.1	<0.01	<0.01	<0.01
Se	<0.01	<0.005	<0.01	<0.025	<0.005	<0.005	<0.025	<0.025	<0.025	<0.025	<0.05	<0.05	<0.025	<0.005	<0.005	<0.005
Si	14	15	12	11	13	9.1	2.1	11	10.00	12.00	14.00	13.00	10	11	16	14
Ag	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Sr	0.9	0.3	1.2	1.5	0.8	0.7	1.8	1.4	0.90	1.70	2.00	1.70	1.3	0.2	0.2	0.4
Tl	<0.002	<0.002	<0.001	<0.002	<0.001	<0.004	<0.004	<0.001	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	<0.001	<0.001
Sn	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
V	0.004	0.011	<0.001	<0.002	0.001	<0.004	<0.004	<0.002	<0.001	<0.001	<0.002	<0.002	<0.01	<0.001	0.011	0.005
Zn	<.02	<0.01	<0.01	<0.02	<0.01	<0.04	<0.04	<0.01	<0.01	<0.01	<0.02	<0.02	<0.1	,0.01	<0.01	<0.01
Sample Date	11/07/94	11/09/94	11/08/94	11/08/94	11/08/94	11/07/94	11/07/94	11/08/94	34646	34646	11/09/94	11/09/94	11/08/94	11/08/94	11/09/94	11/08/94
SLD # (Ions)	wc946413	wc946437	wc946422	wc946433	wc946430	wc946412	wc946416	wc946420					wc946429	wc946421	wc946434	wc946432
SLD # (NO3)	wc946381	wc946408	wc946391	wc946402	wc946399	wc946380	wc946384	wc946389					wc946398	wc946390	wc946403	wc946401
SLD#(Metals)	lc940643	lc940665	lc940653	lc940664	lc940661	lc940642	lc940646	lc940651	lc940649	lc940648	lc940667	lc940666	lc940660	lc940652	lc940665	lc940663

Table 2
Page 6

MOLYCORP MOLYCORP
Ground Water S Ground Water Sample Analyses
MED - Ground NMED - Ground Water Section
ovember 4 - 9, November 4 - 9, 1994
ata reported in (data reported in mg/L except as noted)

	MWA	MWC	CH	002	MMW2	MMW3	MMW7	MMW7dup	MMW8A	MMW8B	MMW10A	MMW10B	MMW10C	MMW11	MMW13
a	166	277.6	42.8	279.6	na	498			184.4	407	231.6	321	192.8	229	258
g	54.2	54.2	12.2	63	na	112			54.7	102.6	90.7	95.1	76.1	104.5	48.9
a	50	78	61	97	81	103			33	41	32	26	25	34	32
CO3	184	194	235	190	<3	255			13	187	<3	22	<3	190	178
O3	<3	3	4	<3	<3	<3			<3	<3	<3	<3	<3	<3	<3
	11	14	<5	11	<5	<5			<5	5	21	22	15	36	13
O4	528	896	65	896	2177	1759			716	1279	1030	1080	849	1267	717
O3	0.4	0.1	0.5	0.1	0.1	0.1			0.8	0.1	6.5	3	4.6	6.2	2.6
	0.4	1.2	0.8	2.1	28	2.8			1.9	2.6	8.3	13.2	17.8	21	1.8
	6	6	4	8	28	10			5	7	14	7	12	20	7
ardness	638	917	157	958	na	1708			686	1440	952	1193	795	1004	847
kalinity	150	158	197	156	<3	209			10	154	<3	18	<3	156	146
ond. (uS/cm)	na	1786	504	1875	3139	2723			1326	2276	1823	3057	1563	1985	1478
(pH units)	8.07	7.79	8.58	6.86	3.86	7.63			5.99	8.07	4.41	6.19	4.53	4.43	6.59
S	8	<3	<3	<3	28	5			<3	7	<3	33	<3	<3	3
S	1036	1608	382	2124	3524	3070			1282	2292	1882	1882	1690	2124	1442
sum	900	1415	297	1440	2258	2597			995	1927	1412	1558	1163	1770	1159
balance (%)	2.46	-0.86	5.88	3.23	-82.90	-2.52			0.29	1.44	-4.01	3.01	-3.23	-16.87	0.19
	<0.1	<0.1	<0.1	<0.1	68	1	950	890	0.4	0.2	33	7.6	31	54	<0.1
	<0.004	<0.004	<0.001	<0.001	<0.01	<0.01	<0.1	<0.1	<0.001	<0.002	<0.01	<0.01	<0.01	<0.01	0.002
	<0.004	<0.004	<0.001	<0.001	0.02	<0.01	<0.1	<0.1	<0.001	0.003.	<0.01	<0.01	<0.01	<0.01	<0.001
a	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	<0.004	<0.004	<0.001	,0.05	0.03	<0.01	0.1	0.1	<0.001	<0.002	<0.01	<0.01	<0.01	0.01	<0.001
	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
d	<0.004	<0.004	<0.001	<0.001	0.02	0.003	0.11	0.11	<0.005	<0.002	0.03	0.02	0.025	0.04	<0.001
	210	390	50	360	600	640	550	540	230	580	290	410	230	260	310
	<0.004	<0.004	<0.001	0.002	<0.01	<0.01	0.2	0.2	<0.005	<0.002	<0.01	<0.05	0.035	<0.01	<0.001
	<0.004	<0.004	<0.001	0.003	0.33	0.08	4.3	3.9	0.003	0.003	0.14	0.08	0.1	0.25	0.011
	<0.04	<0.04	<0.01	<0.01	<0.1	<0.1	4.5	4.5	<0.01	<0.02	0.5	0.2	0.4	0.9	<0.01
	0.4	<0.1	<0.1	<0.1	61	0.1	420	380	<0.1	2.3	<0.1	0.07	<0.1	<0.1	0.2
	<0.004	0.004	<0.001	<0.001	<0.01	<0.01	1	0.8	<0.001	<0.002	<0.01	0.03	<0.01	<0.01	<0.001
	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.005	<0.0005	<0.005	<0.0005	<0.0005	<0.0005	<0.0005
	35	69	9.7	42	150	110	1290	1150	64	110	83	88	82	110	38
	0.037	0.88	0.006	1.9	53	37	69	72	0.23	7.8	15	8.5	16	28	0.91
	0.6	1.2	0.003	2.3	<0.01	<0.01	<0.1	<0.1	<0.001	0.01	<0.01	<0.01	<0.01	<0.1	0.051
	<0.04	<0.04	<0.01	<0.02	0.7	0.2	9.5	8.6	0.06	<0.02	0.3	0.3	0.31	0.6	<0.01
	<0.005	<0.025	<0.01	<0.025	<0.05	<0.05	<0.13	<0.025	0.025	<0.025	<0.05	<0.05	<0.025	<0.005	<0.05
	11	12	10	<1	23	7.1	19	15	19	13	14	13	9.4	12	8.5
	<0.004	<0.004	<0.001	<0.001	<0.01	<0.01	<0.1	<0.1	<0.001	<0.002	<0.01	<0.01	<0.01	<0.01	<0.001
	1.1	2	0.5	2	4.1	4	4.1	3.9	1.3	6.5	1.6	2.1	1.1	1.6	11
	<0.004	<0.004	<0.001	<0.001	<0.01	<0.01	<0.1	<0.1	<0.001	<0.002	<0.01	<0.01	<0.01	<0.01	<0.001
	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	<0.004	<0.004	0.002	<0.001	<0.01	<0.01	0.1	0.1	<0.005	<0.002	<0.01	<0.01	<0.05	<0.5	<0.001
	<0.04	<0.04	0.9	<0.01	10	1.3	9.7	9.8	0.2	<0.02	2.1	1.4	2.9	4.6	0.2
mple Date	11/07/94	11/07/94	11/08/94	11/04/94	11/08/94	11/07/94	11/07/94	11/07/94	11/08/94	11/08/94	11/08/94	11/07/94	11/08/94	11/07/94	11/08/94
D # (Ions)	wc946415	wc946414	wc946423	wc946439	wc946438	wc946427			wc946419	wc946431	wc946425	wc946428	wc946424	wc946440	wc946426
D # (NO3)	wc946383	wc946382	wc946397	wc946385	wc946407	wc946395			wc946388	wc946400	wc946393	wc946396	wc946392	wc946408	wc946394
D#(Metals)	lc940645	lc940644	lc940654	lc940647	lc940669	lc940658	lc940641	lc940640	lc940650	lc940662	lc940656	lc940659	lc940655	lc940639	lc940657

Table 3:

Red River Groundwater Investigation (#92-A)
NPS Project
Organizational Chart

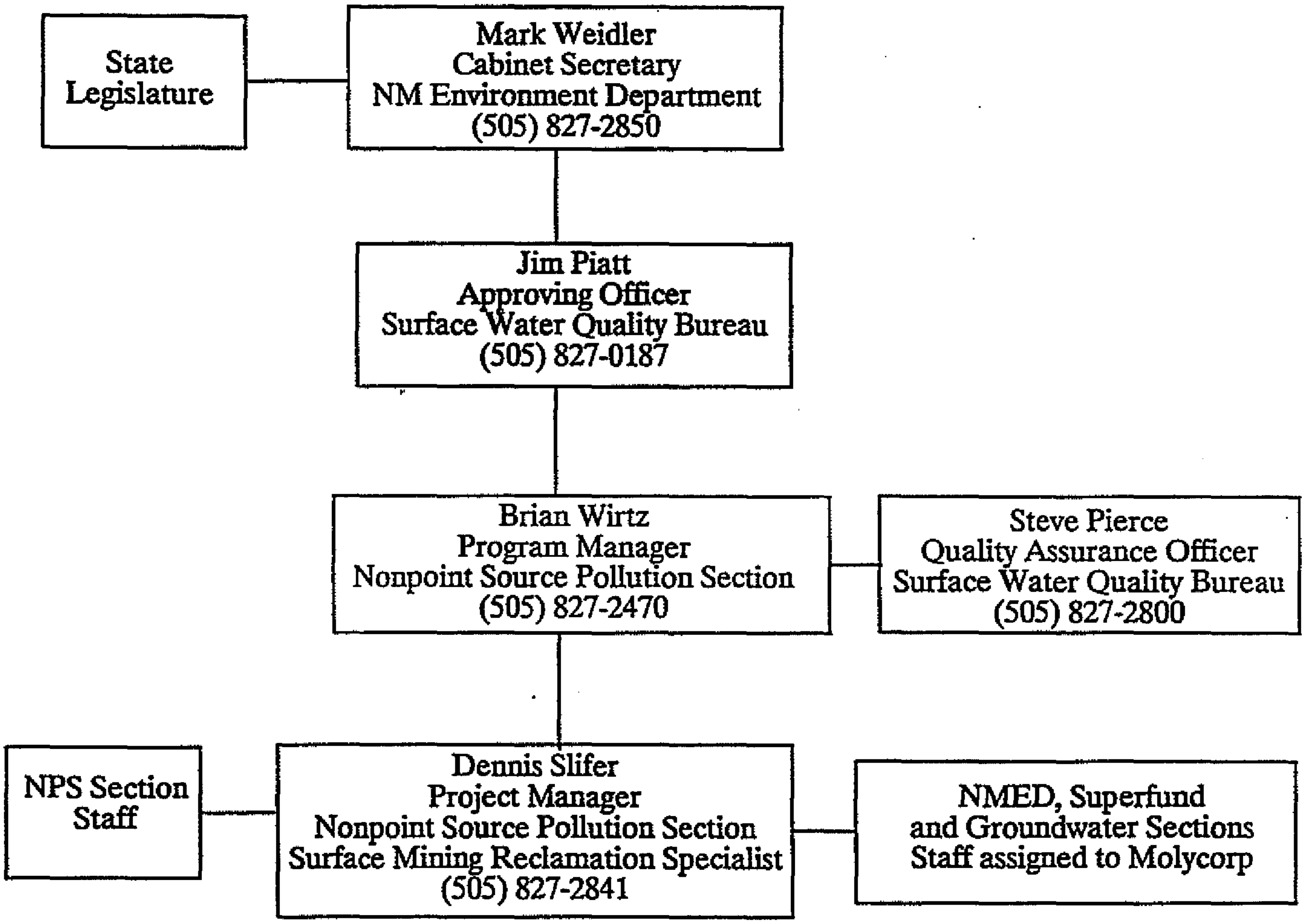


Table 4: List of persons and agencies involved in management of the Red River watershed.

- New Mexico Environment Department (NMED)
  - Surface Water Quality Bureau
    - Nonpoint Source Pollution Section
      - Project Managers: Dennis Slifer, 827-2841
      - Michael Coleman, 827-0505
    - Point Source Regulation Section (NPDES Permits)
      - Program Manager: Glenn Saums, 827-2827
    - Surveillance and Standards Section (stream surveys)
      - Program Manager: Steve Pierce, 827-2800
  - Ground Water Protection and Remediation Bureau
    - Ground Water Section (discharge plans)
      - Karen McCormack (Molycorp DPs), 827-2936
      - Doug Jones (Questa sewage lagoons DP), 827-2903
    - Superfund Section
      - Stewart Kent (Molycorp investigation), 827-0037
  - Taos Field Office (1215-B, Gusdorf Street, Taos)
    - Ken McCallum or Bill King, 758-8808

- New Mexico Office of the Natural Resource Trustee (ONRT)
  - Steve Cary (Deputy Director), 827-0135

- New Mexico Department of Game and Fish (NMDGF)
  - Mike Hatch, 827-7905

- USFS, Carson National Forest, Questa Ranger District
  - Ron Thibideau (District Ranger), 586-0520

- US Bureau of Land Management, Taos Resource Area
  - Sam DesGeorges, 758-8851
- US Bureau of Land Management, Albuquerque Office
  - Joe Mirabal, 761-8731

- Town of Red River
  - Mayor, John Tillery, 754-2277
  - Director of Public Works, Bob Perry, 754-2277

- Village of Questa
  - Mayor, Bobby Ortega, 586-0694

- Molycorp, Questa Mine
  - Mine Manager, Dave Shoemaker, 586-0212

- Amigos Bravos, Taos, NM
  - Brian Shields or Saunee Morris, 758-3874

Table 5 **Assessed Stream Reaches Partially Supporting or Not Supporting Designated or Attainable Uses.**

Red River entries, 1980-1994.

Water Body (Basin, segment) Evaluated or Monitored (E/M)	Year Listed	Uses Not Fully Supported	Probable Causes of Nonsupport	Probable Sources of Nonsupport	Total Size Affected (Miles)
Red River from mouth on Rio Grande to Placer Creek (Rio Grande, 2-119), M	1994	HQCWF	Metals, turbidity, siltation	Agriculture (1500), resource extraction, (5600, 5700, 5900), road construction/ maintenance (8300)	20.2
Red River from Zwergle Dam to confluence of East and West Forks (Rio Grande, 2-120)	1992	HQCWF	Siltation, reduction of riparian vegetation,	Construction (3200), recreation (8700, 8703)	3.9
Red River from Placer Creek to Zwergle Dam (Rio Grande, 2-120)	1992	HQCWF	Metals, total phosphorus, siltation	Construction (3200), resource extraction (5100)	1.6
Red River from mouth on Rio Grande to Placer Creek (Rio Grande, 2-119)	1992	CWF, IRR, L&WW	Metals, turbidity, pathogens, siltation, priority organics	Agriculture (1500), resource extraction (5600, 5700,5900), land disposal (6800)	20.2
Red River from head to Zwergle Dam (Rio Grande, 2-120)	1990	HQCWF	Siltation, nutrients, reduction of riparian vegetation, streambank destabilization	Construction (3200), recreation (8700, 8703)	9.2
Red River from Zwergle Dam to mouth of Placer Creek (Rio Grande, 2-120)	1990	HQCWF	Metals, total phosphorus	Construction (3200), resource extraction (5100)	1.6
Red River from mouth of Placer Creek to Elephant Rock Campground (Rio Grande, 2-120)	1990	HQCWF, DWS, IRR, L&WW	Metals, turbidity, siltation, pH, total phosphorus, pathogens	Construction (3100, 3200, 3201), urban runoff (4000), resource extraction (5900), recreation (8700, 8701)	3.8
Red River from Elephant Campground to Molycorp Mill (Rio Grande, 2-120)	1990	HQCWF, DWS, IRR, L&WW	Metals, turbidity, siltation, pH, total phosphorus, conductivity	Construction (3200), resource extraction (5700), recreation (8700)	3.0
Red River from Molycorp Mill to Red River Fish Hatchery (Rio Grande, 2-119)	1990	HQCWF, DWS, CWF, IRR, L&WW	Metals, turbidity, siltation, pH, total phosphorus, conductivity, reduction of riparian vegetation, streambank destabilization	Construction (3100, 3200), resource extraction (5100, 5600, 5700, 5800, 5900), recreation (8700)	11.0
Red River from Red River Fish Hatchery to mouth on Rio Grande (Rio Grande, 2-119)	1990	CWF, L&WW	Metals, turbidity, siltation	Agriculture (1500), resource extraction (5600)	3.5

Table 5 Assessed Stream Reaches Partially Supporting or Not Supporting Designated or Attainable Uses, continued. Red River entries, 1980-1994.

Water Body (Basin, segment) Evaluated or Monitored (E/M)	Year Listed	Uses Not Fully Supported	Probable Causes of Nonsupport	Probable Sources of Nonsupport	Total Size Affected (Miles)
Red River from Elephant Campground to Molycorp Mill (Rio Grande, 2-120)	1988	HQCWF, DWS, L&WW			3.0
Red River from Molycorp Mill to 1.5 miles above Red River Fish Hatchery (Rio Grande, 2-120)	1988	HQCWF, DWS, L&WW			9.5
Red River from 1.5 miles above Red River Fish Hatchery to mouth on Rio Grande (Rio Grande, 2-119)	1988	CWF			5.0
Red River from Molycorp mine to below Village of Questa (Rio Grande, 2-120)	1986	HQCWF	Metals, turbidity, streambottom deposits, reduction of riparian vegetation	Resource extraction (5100, 5501, 5900)	9.5
Red River from Questa upstream to Town of Red River (Rio Grande, 2-120)	1984	HQCWF	Total phosphorus, streambottom deposits	Municipal point sources (0200), resource extraction (5100, 5501, 5900)	14
Red River from 1.5 miles above bridge at Red River Fish Hatchery to headwaters (Rio Grande, 2-120)	1982		Plant nutrients, streambottom deposits	Industrial wastewater (0100), municipal point sources (0200)	
Red River from the Rio Grande upstream to 1.5 miles above bridge at Red River Fish Hatchery (Rio Grande, 1-119)	1982		Metals, pH, cyanide	Industrial wastewater (0100)	
Rio River from Rio Grande to Town of Red River (Rio Grande, 17 & 18)	1980	HQCWF	Turbidity, pH, cyanide, streambottom deposits, plant nutrients	Industrial point sources (0100), municipal point sources (0200), resource extraction (5000, 5501, 5900)	27

Table 6 Assessed Stream Reaches with Threatened Designated or Attainable Uses. **Red River entries, 1994.**

Water Body (Basin, segment) Evaluated or Monitored (E/M)	Uses Not Fully Supported	Probable Causes of Nonsupport	Probable Sources of Nonsupport	Total Size Affected (Miles)
Red River from Placer Creek to confluence of East and West Forks (Rio Grande, 2-120), M	HQCWF	Siltation, habitat alteration	Agriculture (1500), resource extraction (5100)	13.0
West Fork of Red River from confluence with East Fork to headwaters (Rio Grande, 2-120), E	HQCWF	Siltation. habitat alteration	Recreation (8701)	2.6
Middle Fork of Red River from mouth on West Fork to headwaters (Rio Grande, 2-120), E	HQCWF	Siltation, reduction of riparian vegetation	Recreation (8700, 8701)	1.3

Table 7 Assessed Stream Reaches Partially Supporting or Not Supporting Designated or Attainable Uses.

Tributaries of the Red River entries, 1980-1994.

Water Body (Basin, segment) Evaluated or Monitored (E/M)	Year Listed	Uses Not Fully Supported	Probable Causes of Nonsupport	Probable Sources of Nonsupport	Total Size Affected (Miles)
Bitter Creek from mouth on Red River to headwaters (Rio Grande, 2-120), M	1994	HQCWF	Metals, siltation, reduction of riparian vegetation, streambank destabilization	Agriculture (1500), resource extraction, (5100, 5800), road runoff (8300), recreation (8700)	7.1
Pioneer Creek from mouth on Red River to headwaters (Rio Grande, 2-120), M	1994	HQCWF	Turbidity, siltation, reduction of riparian vegetation, streambank destabilization	Resource extraction, (5200, 5900), recreation (8701, 8705)	4.3
Placer Creek from mouth on Red River to headwaters (Rio Grande, 2-120), E	1994	HQCWF	Siltation, reduction of riparian vegetation, streambank destabilization	Resource extraction (5300, 5900)	1.3
Cabresto Creek from mouth on Red River to headwaters (Rio Grande, 2-120), M	1994	HQCWF	Flow alteration, reduction of riparian vegetation, siltation, turbidity	Agriculture (1200, 1500), road construction/ maintenance (8300)	14.6
Bitter Creek from mouth on Red River to headwaters (Rio Grande, 2-120)	1992	HQCWF	Metals, turbidity, total phosphorus, pH, siltation, reduction of riparian vegetation, streambank destabilization	Resource extraction (5300, 5700), road runoff (8300), recreation (8700)	7.6
Cabresto Creek from mouth on Red River to headwaters (Rio Grande, 2-120), M	1992	HQCWF	Metals	Resource extraction (5100)	14.6
Bitter Creek from mouth on Red River to headwaters (Rio Grande, 2-120)	1990	HQCWF	Turbidity, total phosphorus, pH, siltation, metals	Resource extraction (5100), road runoff (8300), recreation (8700)	7.6
Cabresto Creek from USLM No. 5 Mine to mouth on Red River (Rio Grande, 2-120), M	1990	HQCWF	Metals	Resource extraction (5100)	14.6

Table 8 Assessed Stream Reaches with Threatened Designated or Attainable Uses.

Tributaries of the Red River entries, 1994.

Water Body (Basin, segment) Evaluated or Monitored (E/M)	Uses Not Fully Supported	Probable Causes of Nonsupport	Probable Sources of Nonsupport	Total Size Affected (Miles)
Columbine Creek at its mouth on Red River (Rio Grande, 2-120), M	HQCWF	Siltation, habitat alteration	Recreation (8700)	0.5
Mallette Creek from mouth on Red River to headwaters (Rio Grande, 2-120), M	HQCWF	Turbidity, total phosphorus, metals	Recreation (8700, 8701)	2.3

APPENDICES

Appendix A: Tabulated analytical data for samples collected at Molycorp mine and tailings site by NMED Superfund Oversight Section in 1993/1994, and an evaluation of sulfate gain to Red River excerpted from draft document (NMED, October 23, 1995).

Appendix B: Discussion of Molycorp mine area hydrogeology, excerpted from SPRI Report, April 21, 1995.

Appendix C: Report on the installation and testing of 12 new monitoring wells at Molycorp mine in 1994, excerpted from SPRI Report, April 21, 1995.

Appendix D: Water quality results from 1994 sampling at Molycorp mine, excerpted from SPRI Report, April 21, 1995.

Appendix E: Summary report on latest hydrogeological studies and sampling at Molycorp tailings area, excerpted from SPRI Report, April 13, 1995.

Appendix F: Summary of geochemical assessment for acid rock drainage potential at Molycorp mine, excerpted from SRK Report, April 13, 1995.

Appendix G: Selected tables and figures pertaining to Red River water quality from Garrabrant, 1993, USGS Water Resources Investigation Report 93-4107.

Appendix H: Report on installation of anoxic limestone drains at Red River and Capulin Canyon in October, 1995.

Appendix I: News media articles about Red River and Molycorp from the time period of this project (1994-1995).

P-1

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: Red River Groundwater Inv.		
Date: July 1994	Time:	Photographer's Name: D. Slifer

Site Location:

lower Red River gorge from confluence

Description:

View of lower Red River gorge looking east from confluence with Rio Grande. Taos Range in background

Site Location:

confluence of Red River and Rio Grande

Description:

This area is designated as a Wild and Scenic River area by the B.L.M.

P-2

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

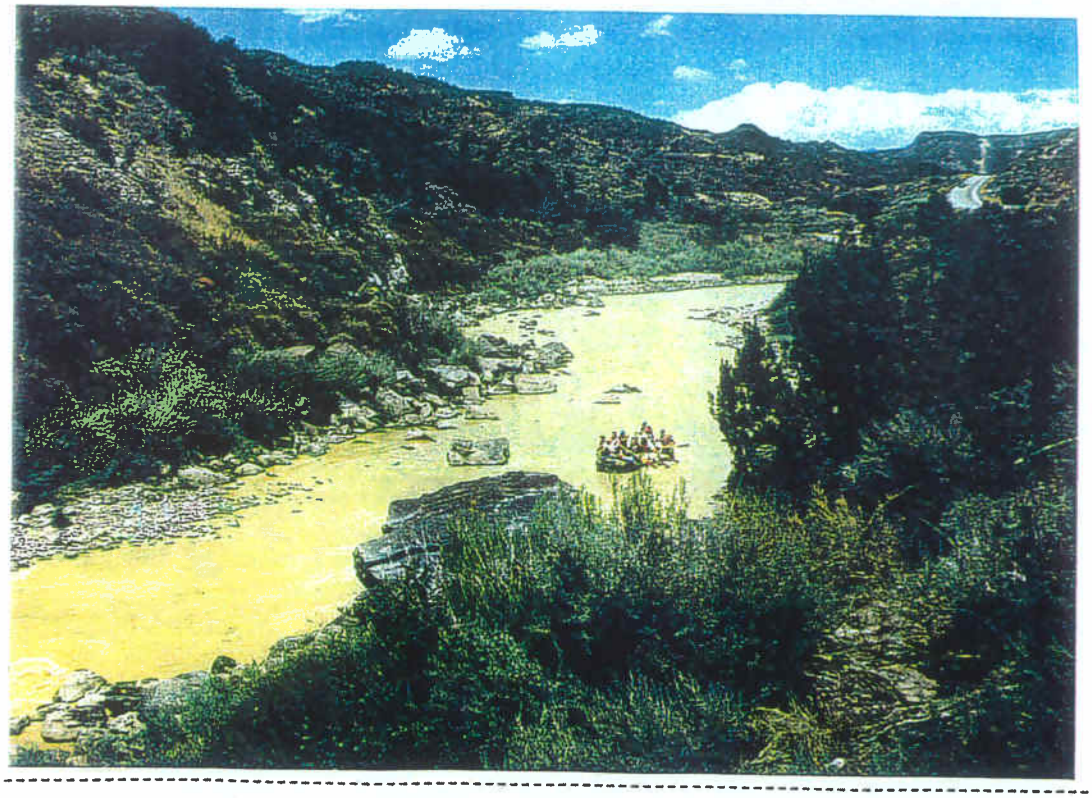
PROJECT: RRGI		
Date: 8/31/94	Time: 9:00	Photographer's Name: D. Slifer

Site Location:

Confluence of Red River and Rio Grande

Description:

Red River (left) is extremely turbid following a storm. Rio Grande (right) is clear until the Red River flow enters.



Site Location:

Rio Grande near Pilar NM

Description:

Extreme Turbidity from storm runoff in Red River area (at least 50 river miles upstream) is still evident in Rio Grande.

P-3

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 1995	Time:	Photographer's Name: D. Slifer

Site Location:

Questa, NM

Description:

View of 2 of 5 sewage lagoons at Questa. The Red River is located in line of trees below lagoons. Molycorp tailings dam in background

Site Location:

Valley of Pines Subdivision

Description:

Example of the development in upper Red River Valley. River is in lower right. Hundreds of houses are located adjacent to the river.

P-4

State of New Mexico

ENVIRONMENT DEPARTMENT

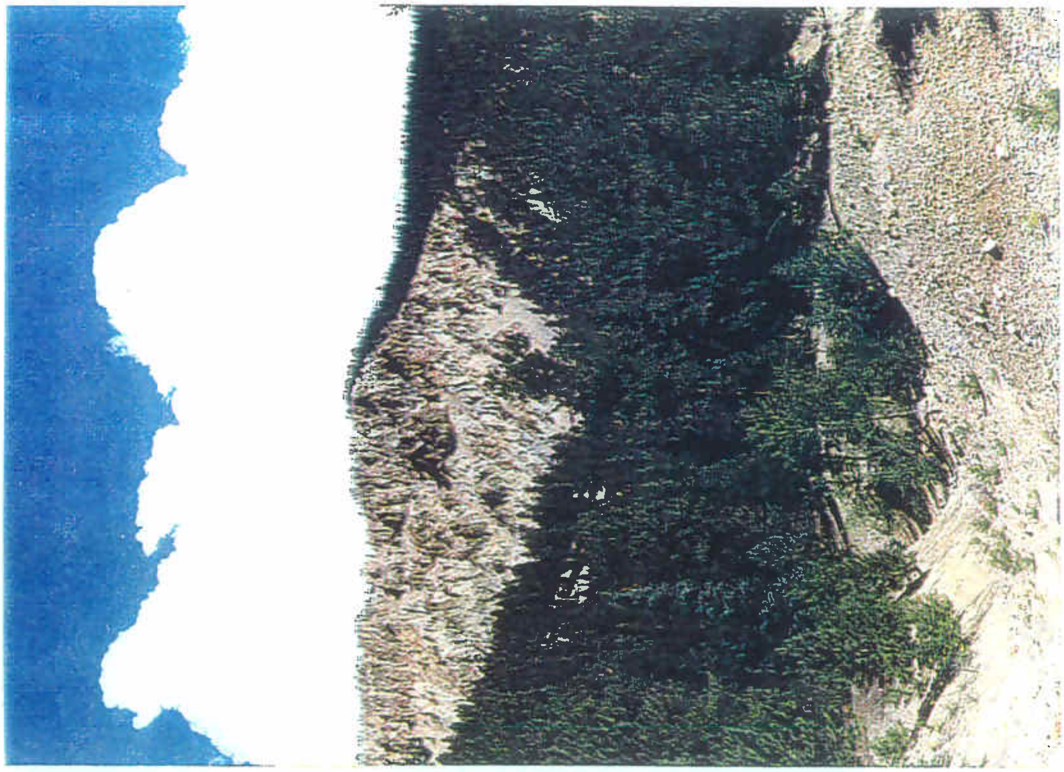
Photograph Record

PROJECT: RRGI

Date: 8/95

Time:

Photographer's Name: D. Slifer



Site Location:

Haut-N-Taut drainage

Description:

Example of the hydrothermal alteration scar areas developed in middle reach of Red River.

Site Location:

Hansen Creek drainage

Description:

acid rock drainage flowing from scar area at Hansen Creek upstream of Molycorp Mine.

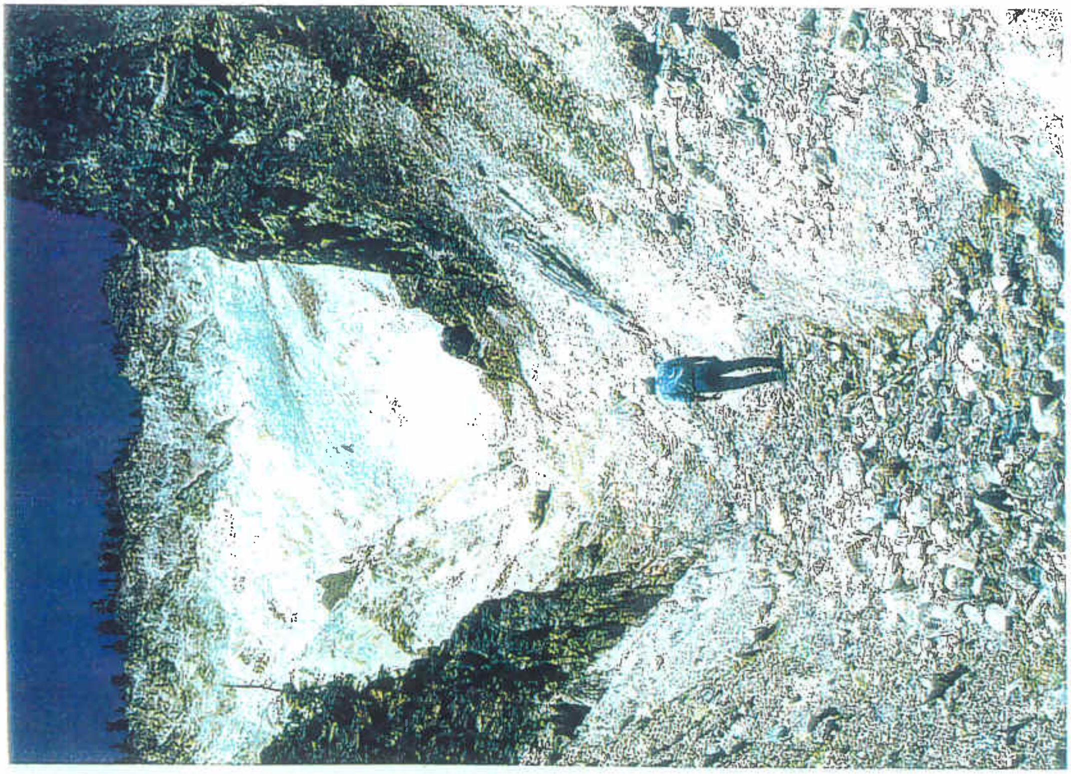
P-5

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 6/94	Time:	Photographer's Name: D. Slifer



Site Location:

Bitter Creek scar

Description:

Erosion channel and ARD seep area near head of scar (debris flow) on Bitter Creek

Site Location:

Bitter Creek scar/debris flow area

Description:

Live pine tree showing channel fill & cut on trunk. Note flow of ARD in channel

P-6

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

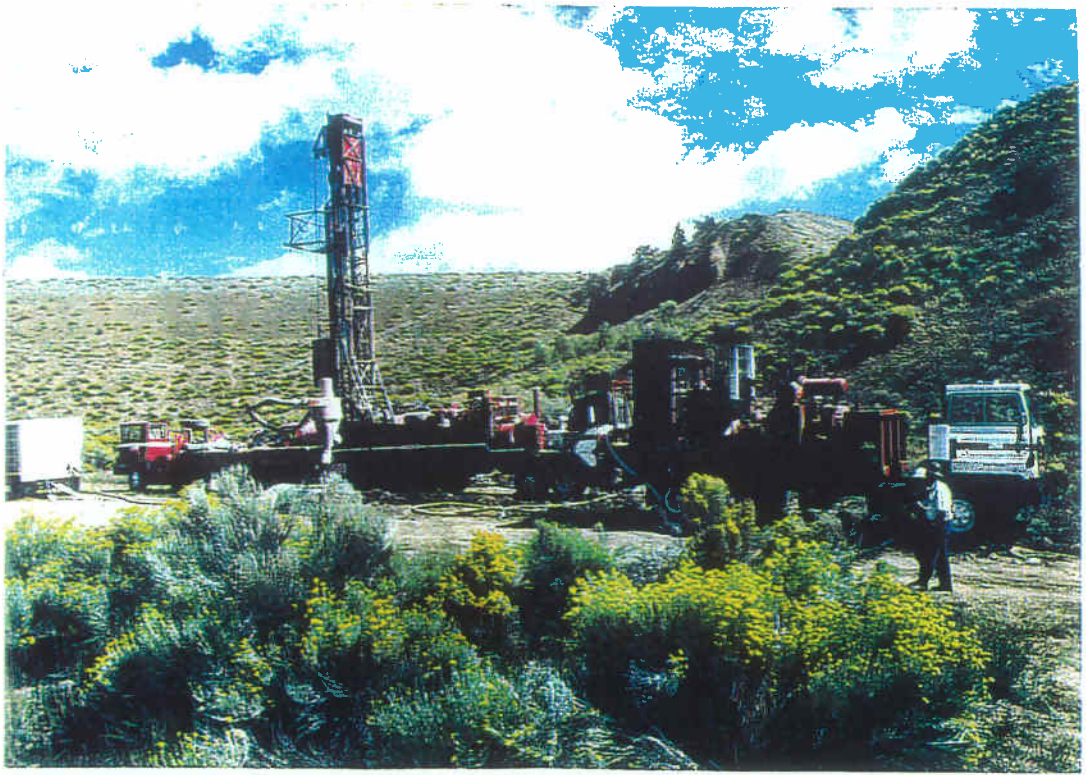
PROJECT: RRGI		
Date: 3/94	Time:	Photographer's Name: D. Slifer

Site Location:

Red River at Questa Ranger Station

Description:

Typical blue color of river (due to aluminum compounds) at USGS gage by Questa Ranger Station.



Site Location:

Molycorp tailings area

Description:

Drilling new monitor/extraction wells at toe of tailings dam, near seepage collection system (Summer 1994)

P-7

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 1994	Time:	Photographer's Name: D. Slifer

Site Location:

Molycorp Mine

Description:

View into the open pit, looking SW. The west wall has numerous streams of acidic drainage flowing down it into the base of pit

Site Location:

Molycorp Mine

Description:

View of waste rock dumps at Sugar Shack area showing the proximity to Red River. View to west.

State of New Mexico
ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 1995	Time:	Photographer's Name: D. Slifer

Site Location:

Molycorp Mine

Description:

Goathill Gulch (looking north) showing caved area (arrow) and drainage course of collected ARD seepage into underground mine

Site Location:

Molycorp Mine

Description:

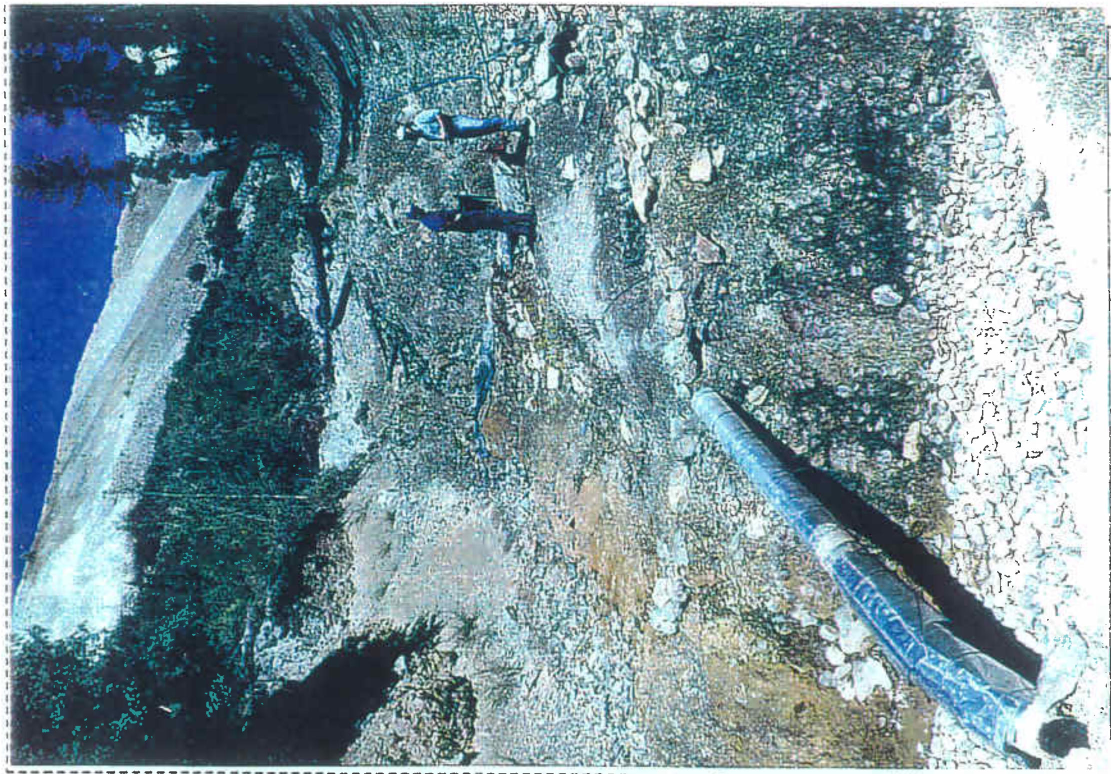
Waste rock dumps in upper Goathill Gulch and Capulin Canyon.

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 1994	Time:	Photographer's Name: D. Slifer

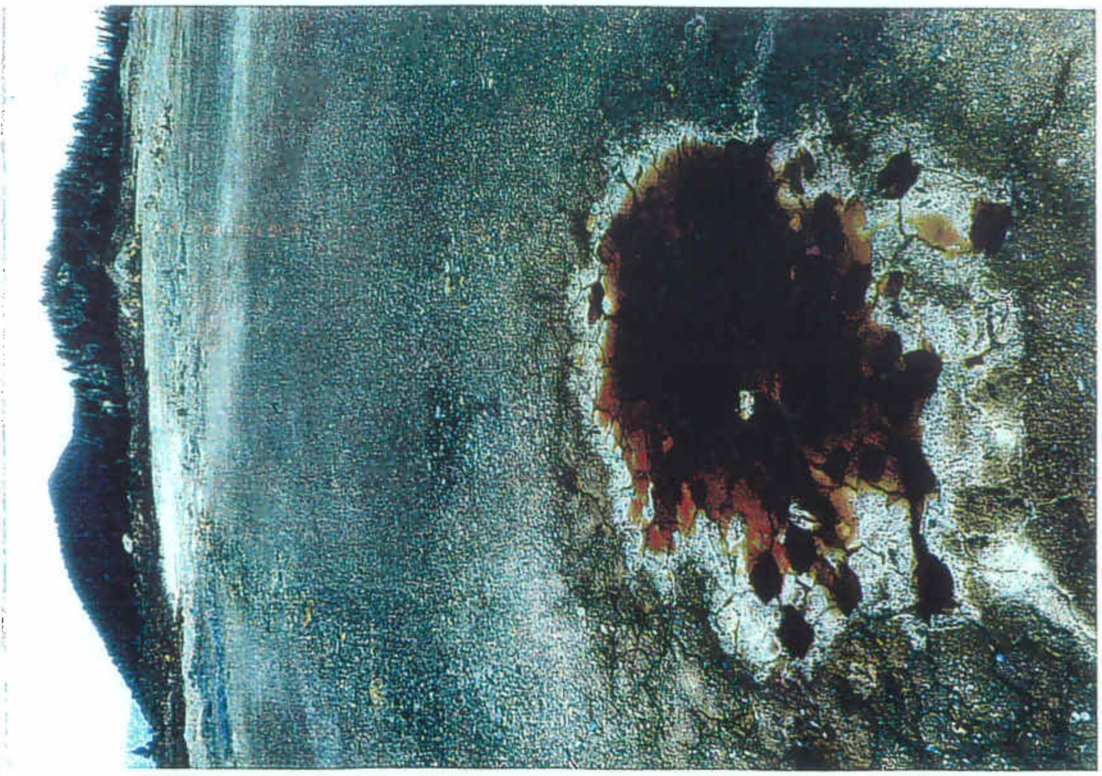


Site Location:

Molycorp Mine

Description:

Part of the seepage collection system installed at toe of waste rock dumps in Capulin Canyon



Site Location:

Molycorp Mine

Description:

Pool of highly acidic water (pH 1.5) on top of Capulin waste dump. Note the elk tracks in pool. (Aug. 95)

P-10

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 1994/5	Time:	Photographer's Name: D. Slifer

Site Location:

Capulin Canyon at Red River

Description:

ARD seepage area in old (abandoned) river channel near mouth of Capulin Canyon. Iron compounds cause reddish color.

Site Location:

Capulin Canyon at River

Description:

Same as above. Water is pH 3.3 and TDS = 3000. Planned anoxic drain is intended to treat this area (and others nearby) (Aug. '95)

P-11

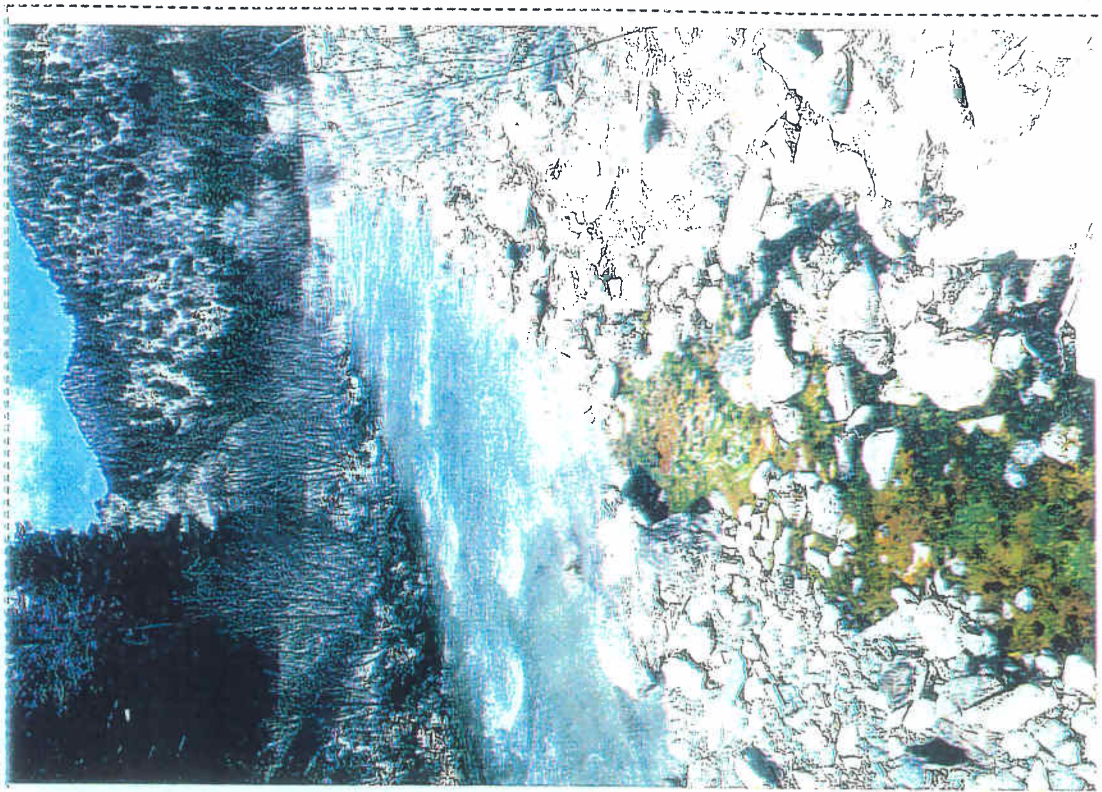
State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI

Date:	Time:	Photographer's Name:
94/95		D. Slifer



Site Location:

Seep at mouth of Capulin Canyon

Description:

View of Red River (to west) and acid seep. River has bluish/milky color from seeps. Algae colors seep green, and iron precip. is red.

Site Location:

Seep at mouth of Capulin Canyon

Description:

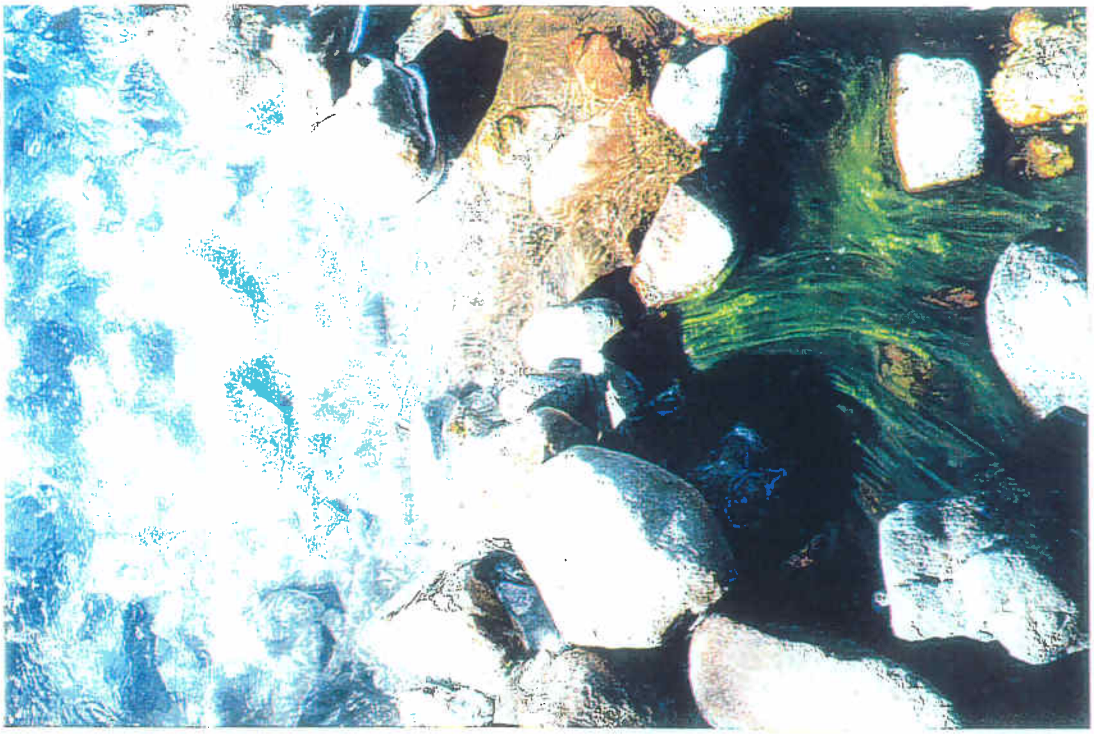
Red River (to W.) and acid seep. Iron stains the alluvium red, and aluminum compounds leave white precipitate.

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 94/95	Time:	Photographer's Name: D. Slifer



Site Location:

Seep at mouth of Capulin Canyon

Description:

Close-up view of seep water (on bottom of photo) entering Red River. Note white & red precipitates on substrate of river.

Site Location:

Seep opposite the Moly Tunnel (Portal Spring)

Description:

Seep discovered in 1994 (5-13 in Table 1). Red River or right (note white precipitate), seep is full of green algae

(Jan. 94)

P-13

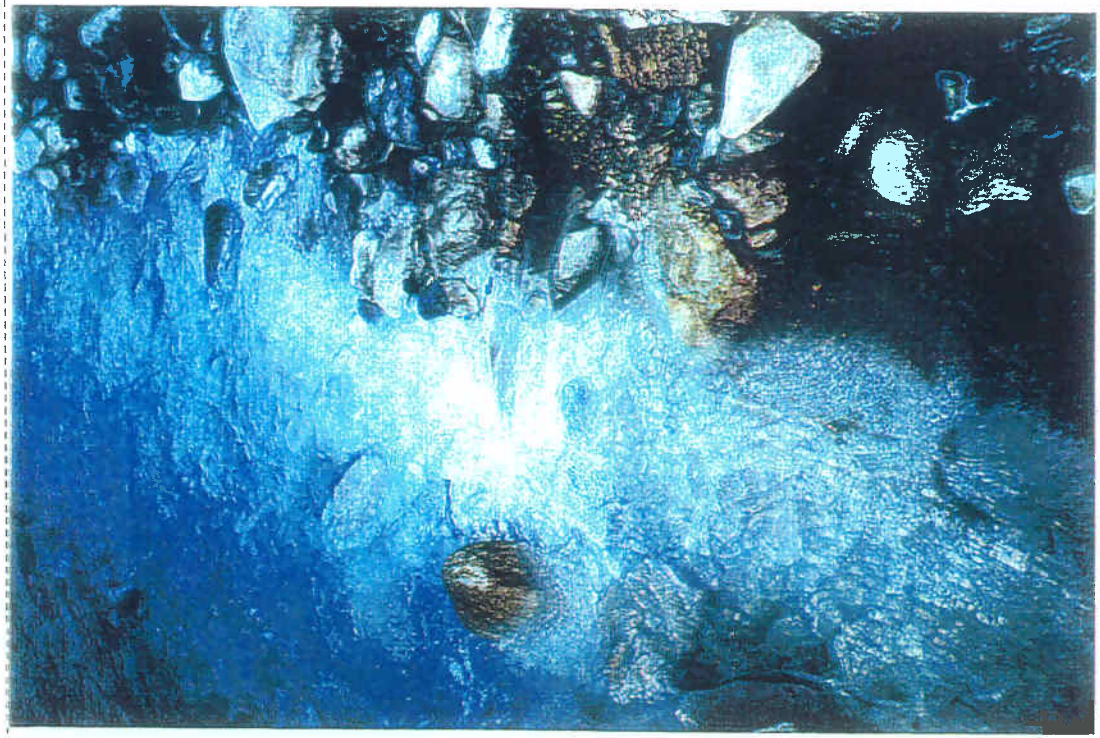
State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI

Date:	Time:	Photographer's Name:
9/93		D. Slifer

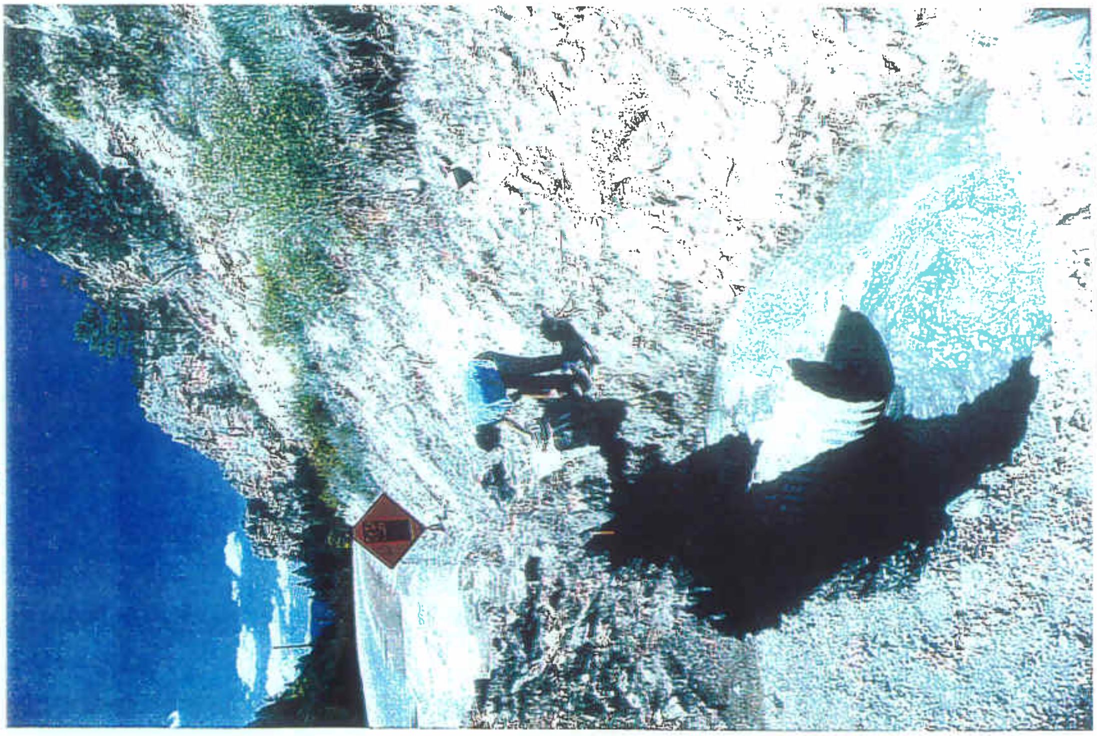


Site Location:

Seep at mouth of Capulin Canyon

Description:

Close-up of Red River showing white precipitate from seep (due to aluminum compounds). Seep is on right of photo.



Site Location:

Seep at mouth of Capulin Canyon.

Description:

Excavation of the highway in 9/21/93 exposed contaminate groundwater at depth of 5', from ARD in alluvium. Data is in Table 1 (sample 35).

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 93/95	**Time:**	**Photographer's Name:** D. Slifer

Site Location:

Pioneer Creek

Description:

Mine drainage from old gold mine on Pioneer Creek (tributary) to Red River.

(Aug' 93)

Site Location:

Bitter Creek

Description:

Drainage from old mine (entrance) in upper Bitter Creek.

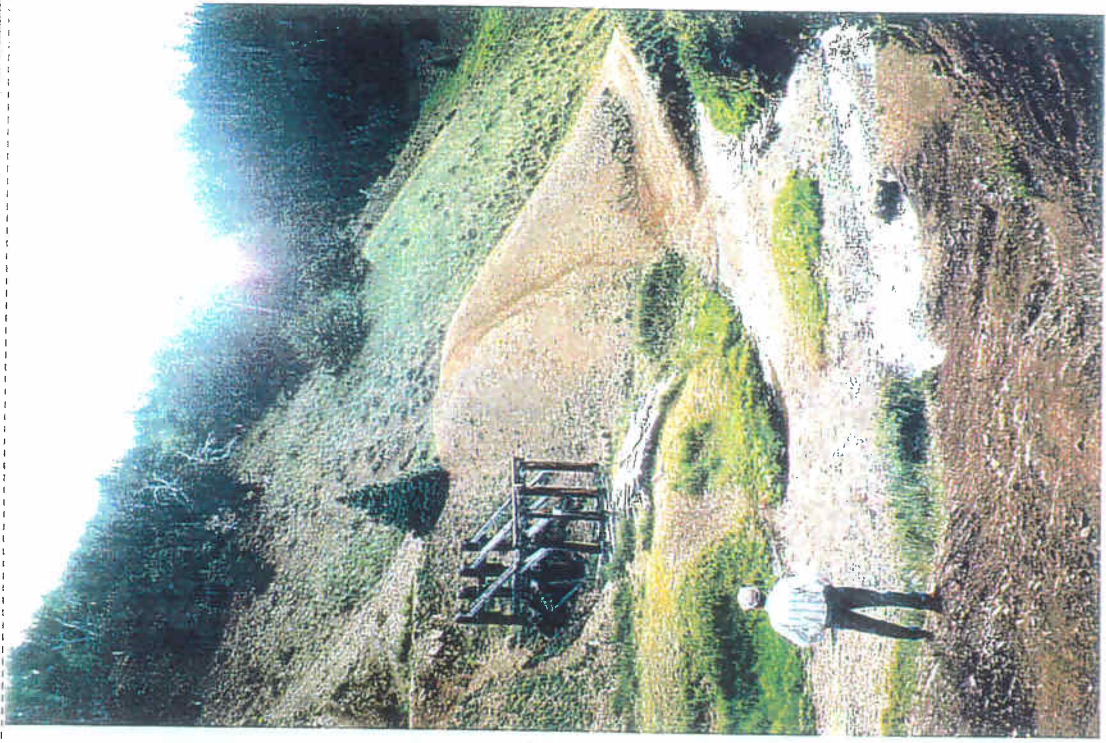
(8/95)

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 8/95	Time:	Photographer's Name: D. Slifer



Site Location:

Anchor Mine on Bitter Creek.

Description:

One of many old gold mines in upper Bitter Creek Note waste rock adjacent to stream.

Site Location:

Oro Fino mine on Bitter Creek.

Description:

Both waste rock and mill tailings are present here. ARD was treated with an anoxic limestone drain in 1994 (bottom center of photo) as a demonstration BMP.

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State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 94/95	Time:	Photographer's Name: D. Slifer

Site Location:

Oro Fino mine on Bitter Creek.

Description:

Sampling treated ARD from discharge pool of BMP (anoxic drain) that was installed in 1994. Mine waste and mill tailings in background.

Site Location:

Bitter Creek

Description:

Drainage from entrance of old gold mine on upper Bitter Creek (above first pond)

8/95

P-17

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI

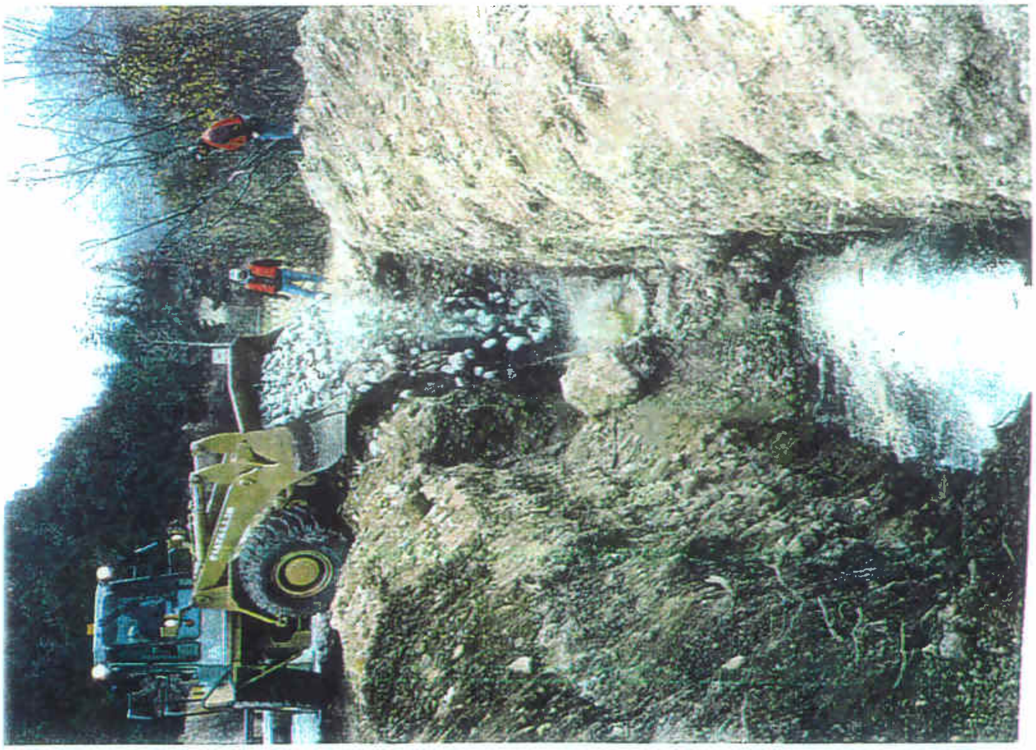
Date:	Time:	Photographer's Name:
10/31/95		D. Slifer

Site Location:

Red River at Capulin Canyon

Description:

Excavation of trench for anoxic drain. Water table (seep) at ~10' depth. Note iron-stain sediments. Water pH=3.5, cond=1600



Site Location:

Red River at Capulin Canyon

Description:
Anoxic drain being constructed. Crushed limestone, plastic liner & clay layer went in trench before backfilling. Acid seep water in bottom of trench.

State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 10/31/95	Time:	Photographer's Name: D. Slifer

Site Location:
Red River at
Capulin Canyon

Description:
Anoxic drain
being constructed
to intercept acid
seeps next to
river (on right)
Limestone being
placed in trench
view to east.

Site Location:
Red River at
Capulin Canyon

Description: BMP -
Anoxic drains to
treat acid seeps
next to river.
Trenches approx
12' deep, 6' wide,
50' to 70' long.
view to west.

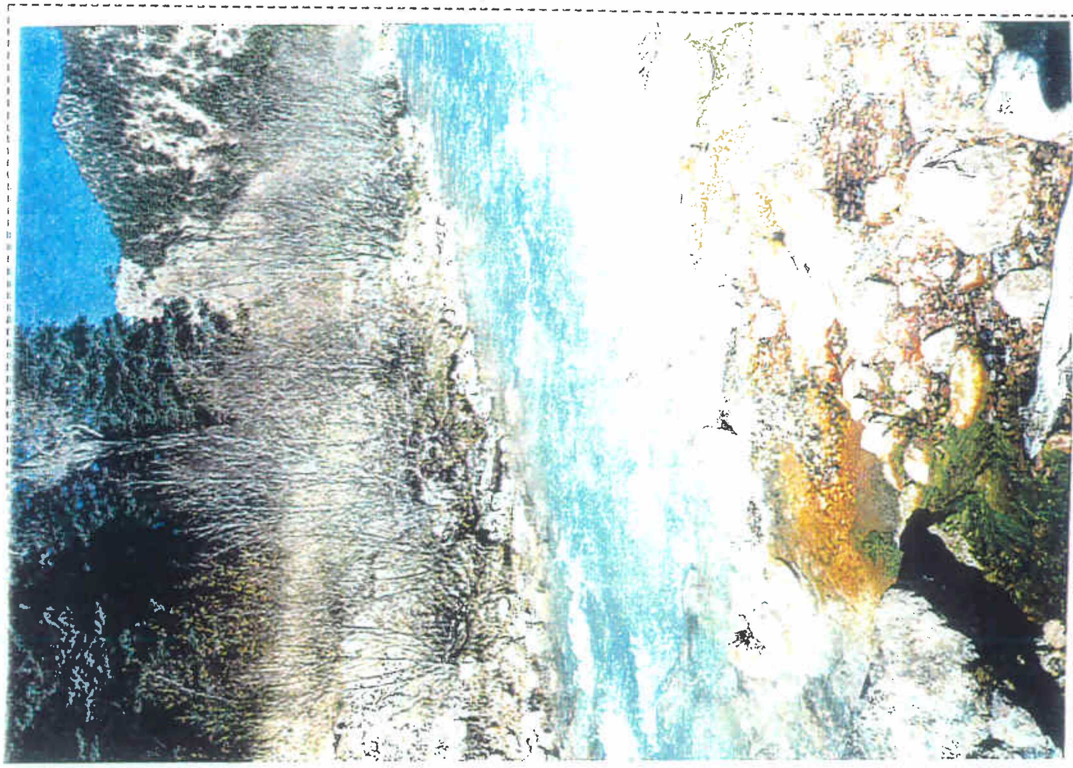
State of New Mexico

ENVIRONMENT DEPARTMENT

Photograph Record

PROJECT: RRGI		
Date: 10/30/95	Time:	Photographer's Name: D. Slifer

←



Site Location:

Red River at Capulin Canyon

Description:

Acid seep on northbank of river is indicated by iron staining and algae. River color due to Al compounds from seeps (pH 3.5)

Site Location:

Red River at Capulin Canyon

Description:

Same as above, close-up view. Seep on bottom, river water at top. White precipitate due to aluminum compounds from seepage water.

←

P-20

Aerial view of the Molycorp Questa Mine, showing open pit (right), waste-rock dumps (left), mill facilities (bottom), and tailings impoundments ten miles distant at Questa (light-colored area at top center). The Red River, barely visible in this photograph, flows parallel to Highway 38 in lower left of picture. View is to the west. Photograph by LightHawk, Santa Fe, New Mexico.

APPENDIX A

Tabulated analytical data for samples collected at Molycorp mine and tailings site by NMED Superfund Oversight Section in 1993/1994, and an evaluation of sulfate gain to Red River excerpted from draft document (NMED, October 23, 1995).

(goes with App. A) →

Table 1. Metal Concentrations in Mine Waste Dumps (mg/kg)

Map Location Date Sampled CLP # Analyte (mg/Kg)	P Capulin Waste Dump #1 6/27/94 SF5804	Q Capulin Waste Dump #2 6/27/94 SF5805	R Goathill Waste Dump 6/27/94 SF5806	S Sugar Shack West Dump 6/28/94 SF5816	T Sugar Shack South Dump 6/28/94 SF5819	U Along Truck Shop Road 6/28/94 SF5817	V Along Lower Bench Road 6/28/94 SF5818	Average Waste Dump Concentration (# of samples=7)	Coefficient of Variation (%)
Al	1910	2730	5860	6190	18900	9130	5810	7219	73
Sb	nd	nd	nd	nd	nd	nd	nd	nd	na
As	2.6Jv	2.5Jv	11.4Jv	1.6Jv	0.86Jv	na	1.1Jv	3	124
Ba	45.2	171	46.2	27.5	246	41.2	4	83	100
Be	0.25	0.27	0.27	0.59	0.63	0.89	1.3	1	60
Cd	nd	nd	nd	nd	nd	nd	3.9	1	245
Ca	195	1350	2280	8860	18400	8670	15100	7836	83
Cr	-	4.6	17.5	10.4	81.7	17	nd	19	142
Co	-	2.4	3.5	5.6	9	13.3	2.9	5	80
Cu	26.3	45.4	41.6	126	140	222	92.5	99	65
Fe	13800	16800	27700	22700	46000	25400	7830	22890	50
Pb	431	40.2	91	61	31.1	40.8	275	139	103
Mg	265	1800	3610	4300	18700	4700	1250	4946	118
Mn	64.5	155	473	432	362	293	1080	409	75
Hg	nd	nd	nd	nd	nd	nd	nd	nd	na
Ni	nd	5.5	12.7	12.2	26.9	21.7	3.7	12	76
K	1620	2180	2550	2540	12300	2550	1020	3537	102
Se	na	1.5J	0.43J	0.35J	nd	nd	nd	3	69
Ag	3.2J^	2.9J^	4	nd	4.6	3J^	nd	1	159
Na	27.5	40.5	67	99.9	183	56.1	43.8	74	67
Tl	na	na	na	na	2.4Jv	na	na	2	0
V	1.3	5.8	12.7	14.9	83.3	16.2	3.4	20	135
Zn	86.5	20.8	53.3	66.3	35.4	43.3	569	125	146
Mo	9.3	6.1	24	10.8	168	176	207	86	100
Field ID #	SS-4	SS-5	SS-6	SS-7	SS-8*	SS-9	SS-10		

nd = not detected
J = estimated value;
^ = value biased high; v = value biased low
na = not available (data unusable or value cannot be calculated)
* Sample was labelled SS-11 on chain of custody

Table 2. Metal Concentrations in Tailings

MapLocation	6	7	8	4	5	3	1	2		
Tailings Pond	TP-1	TP-1	TP-2	TP-5A	TP-5A(dupl)	TP-4	TP-4	TP-4	Average Conc. (mg/kg)	Coefficient of Variation
Field Station	S-12	S-13	S-14	S-10	S-10A	S-11	S-8	S-9		
CLP ID#	MFT923	MFT924	MFT925	MFT926	MFT927	MFT928	MFT929	MFT930		
Analyte (mg/Kg)										
Al	6190	16300	3850	5620	6220	11000	8150	7070	8050	45.7
Sb	ND	ND	ND	ND	ND	ND	ND	ND	0	na
As	ND	ND	1.2^J	ND	1.4^J	ND	1.1^J	ND	0.78	46.9
Ba	70.4	153	29.9	73.9	90.6	125	78.1	74.8	87.0	40.1
Be	0.59	2.4	0.46	0.47	0.56	1.3	0.79	0.72	0.9	67.7
Cd	ND	ND	ND	ND	1.2	ND	ND	ND	0.2	264.6
Ca	14500	17900	10200	18800	19700	17700	15700	15500	16250.0	17.4
Cr	32.9	77.1	19.4	28.5	31	55.8	40.5	36.3	40.2	42.4
Co	8.1	7.9	3.6	14.7	16.2	7.4	12.9	12.4	10.4	38.6
Cu	136	169	37.7	262	274	324	196	109	188.5	47.2
Fe	13100	19700	8640	19400	20800	16600	18500	16800	16692.5	22.6
Pb	31.3	51.8	33.2	82.2	82.8	67.8	71.4	40.7	57.7	34.4
Mg	6300	14300	3870	5730	6180	10100	8330	7130	7742.5	39.0
Mn	352	692	515	386	413	546	461	406	471.4	21.9
Hg	ND	ND	ND	ND	ND	ND	ND	ND	0.0	na
Ni	24.6	42	10.5	30.5	34.9	35.4	31.2	29.8	29.9	29.2
K	4010	8490	1910	3680	3970	6230	5340	4460	4761.3	38.6
Se	ND	ND	ND	ND	ND	ND	ND	ND	0.0	na
Ag	ND	ND	ND	ND	ND	ND	ND	ND	0.0	na
Na	118	222	78.6	119	117	173	130	140	137.2	29.5
Tl	0.42	0.82	ND	0.42	0.53	0.64	0.58	0.42	0.5	46.4
V	30.2	61.8	13.6	26.5	30.4	46.2	37.9	33.8	35.1	38.1
Zn	85.1J	115J	111J	156J	148J	140J	158J	104J	127.1	19.9

J - estimated value; ^ value biased high
ND - undetected; na - not available or calculable

Table 3. Metal Concentrations in Hydrothermal Scars (mg/kg)

Map Location	M Eagle Rock Scar Area	N Eagle Rock (duplicate)	O Goathill Scar	W Hanson Crk Scar	Average Scar Concentration (# of samples=4)	Coefficient of Variation (%)
Date Sampled	6/27/94	6/27/94	6/27/94	6/26/94		
CLP ID#	SF5897	SF5899	SF1801	SF5860		
Analyte (mg/Kg)						
Al	10300	7770	2220	8210	7125	42
Sb	nd	nd	nd	nd	nd	na
As	na	na	21.2Jv	11.5Jv	16.4	30
Ba	147	131	106	248	158	34
Be	0.52	0.44	0.12J^	0.42	0.4	41
Cd	nd	nd	nd	nd	nd	na
Ca	5590	7680	81.9	8810	5540	61
Cr	47	44.8	nd	12.8	26	78
Co	2.4	2.4	3.7	4.6	3	28
Cu	31.4	31.3	52.4	35.1	38	23
Fe	40200	43500	156000	61500	75300	63
Pb	42.5	45.9	134	138	90	51
Mg	4140	3370	192	7100	3701	66
Mn	200	173	17.7	258	162	55
Hg	nd	nd	nd	nd	nd	na
Ni	12.6	9.1	nd	12.4	9	60
K	6250	5630	23700	3300	9720	84
Se	3.6J	3.7J	3.4J	2.2J	3	19
Ag	3.8J^	4.1	12.5	6	6	80
Na	908	1200	1200	689	999	22
Tl	2.1Jv	na	2.9Jv	na	3	16
V	43	37.7	16.2	18.6	29	40
Zn	31.4	27.5	23.9	55.9	35	36
Mo	7.5	9.6	35.6	16.6	17	64
Field ID #	SS-1	SS-2	SS-3	SS-12		

nd = not detected
J = estimated value;
^ = value biased high; v = value biased low
na = not available (data unusable or value cannot be calculated)

Table 4. Ratio of Metal Concentrations between Waste Sources and Background Soil

Analyte (mg/Kg)	Average Metal Concentration: Waste Dumps (N=7)	Average Metal Concentration: Scars (N=4)	Ratio of Concentrations (waste dump/scar)	Average Metal Concentration: Tailings (N=8)	Average Metal Concentration: Background Soil Sedillo Soil Type* (N=3)	Ratio of Concentrations (tailings/backgroud) Sedillo Soil Type	Average Metal Concentration: Background Soil Silva Soil Type* (N=3)	Ratio of Concentrations (tailings/backgroud) Silva Soil Type
Al	7219	7125	1.0	8050	2887	2.8	10813	0.7
Sb	nd	nd	na	0	2.4	na	nd	na
As	3	16.4	0.2	0.78	0.78	1.0	4.9	0.2
Ba	83	158	0.5	87.0	48.7	1.8	167	0.5
Be	1	0.4	1.6	0.9	0.18	5.0	0.8	1.1
Cd	1	nd	na	0.2	nd	na	0.4	0.4
Ca	7836	5540	1.4	16250	1111	14.6	2477	6.6
Cr	19	26	0.7	40.2	3.5	11.5	14.8	2.7
Co	5	3	1.6	10.4	3.0	3.4	12.1	0.9
Cu	99	38	2.6	188	6.3	29.9	23.6	8.0
Fe	22890	75300	0.3	16693	7177	2.3	20633	0.8
Pb	139	90	1.5	57.7	12.6	4.6	22.9	2.5
Mg	4946	3701	1.3	7743	1051	7.4	2787	2.8
Mn	409	162	2.5	471	298	1.6	783	0.6
Hg	nd	nd	na	0.0	nd	na	nd	na
Ni	12	9	1.4	29.9	3.8	7.9	12.3	2.4
K	3537	9720	0.4	4761	1049	4.5	2330	2.0
Se	3	3	1.1	0.0	nd	na	1.1	0.0
Ag	1	6	0.2	0.0	nd	na	nd	na
Na	74	999	0.1	137	38.5	3.6	90	1.5
Tl	2	3	1.0	0.5	nd	NA	nd	na
V	20	29	0.7	35.1	7.9	4.5	36.8	1.0
Zn	125	35	3.6	127	33.5	3.6	66.4	1.9

*ref. SCS 1982; ND - not detected; na - not available (cannot be calculated)
N = Number of Samples

Table 5. Metal Concentrations in Fagerquist Well (Nearest to Mine) and Surrounding Surface/Ground Waters

	Fagerquist Well*	Columbine Creek	Columbine C.G. Well*	Molycorp MW-8b**	Molycorp MW-10a**	Molycorp MW-10c**
Date Sampled	9/9/93	11/7/94	8/24/93^	11/8/94	11/8/94	11/8/94
Side from Red River	south	south	south	north	north	north
Analyte (mg/L)						
Al	<0.1	0.05	<0.1	0.44	33.4	31.1
Sb	na	<0.003	na	<0.05	<0.05	<0.05
As	<0.005	<0.0012	<0.005	<0.05	<0.05	<0.05
Ba	<0.1	0.042	<0.1	0.016	<0.01	0.014
Be	<0.1	<0.0004	<0.1	0.008	0.008	0.007
Cd	<0.001	<0.004	<0.001	<0.0005	0.03	0.03
Ca	24	23	26	206	275	204
Cr	<0.005	<0.004	<0.005	<0.01	<0.01	<0.01
Co	<0.05	<0.005	<0.05	<0.01	0.15	0.11
Cu	<0.05	<0.003	<0.05	<0.01	0.56	0.38
Fe	<0.1	0.05	<0.1	<0.05	<0.05	<0.05
Pb	<0.005	<0.0009	0.01	<0.002	<0.002	<0.002
Mg	2	2.3	2.6	55.5	77.9	75.2
Mn	<0.05	<0.002	<0.05	0.2	13.8	16.3
Hg	<0.0005	<0.0002	<0.0005	<0.0002	<0.0002	<0.0002
Ni	<0.1	<0.017	<0.1	0.06	0.33	0.03
K	1	0.8	2	2.9	2.8	2.8
Se	<0.005	<0.001	<0.005	<0.005	<0.005	<0.005
Ag	<0.1	<0.004	<0.1	<0.1	<0.1	<0.1
Na	2	2.1	3	33.9	26.5	20.2
Tl	na	<0.004	na	<0.005	<0.005	<0.005
V	<0.1	<0.0009	<0.1	<0.01	<0.01	<0.01
Zn	<0.05	0.003	1.6	0.2	2.3	3.2
pH	8.15	/	7.51	6.4	5.8	4.7
Conductivity (umhos)	142	80	169	1780	2400	2000
Depth of Well	52'	na	80'	129'	144'	50'

* unfiltered sample collected by NMED-Surface Water Bureau

** filtered sample collected by South Pass Resources, Inc.

Table 6. Background Metal Concentrations for Determining a Release to Alluvium Aquifer via Seeps

	Red River WWTP	Molycorp Mill Well	Average Conc. for Background Purposes	Red River WWTP	Molycorp Mill Well	Average Conc. for Background Purposes	Background Seep @ Hanson Crk.*
CLP ID#	MFQ267	MFQ270		MFQ262	MFQ265		
Temp (C)				11	6		25
pH				3.85**	6		4
Cond. (umhos)				1200	202		1232
	Filtered	Filtered	Filtered	Unfiltered	Unfiltered	Unfiltered	Unfiltered
Analyte (ug/L)							
Al	36500	144	18322	36700	716	18708	2600
Sb	-	-	-	-	-	-	na
As	-	-	-	-	-	-	na
Ba	11.1	21	16	5.3	22.2	13.75	na
Be	5.1	-	2.6	5.2	-	2.6	na
Cd	6.1J	-	3.1	7.8J	-	3.9	< 5
Ca	151000	43700	97350	151000	45700	98350	156000
Cr	5.8	-	2.9	8.5	-	4.25	na
Co	97.4	-	49	101	-	50.5	na
Cu	58.3	4.9	32	60.8	21.6	41.2	25
Fe	30100		30100	30200	273	15237	430
Pb	3.7J^	-	1.4	3.6J^	3.1J^	3.4	4
Mg	51500	8880	30190	52200	9190	30695	18000
Mn	5700	110	2905	5720	108	2914	445
Hg	-	-	-	-	-	-	na
Ni	227	-	114	232	-	116	na
K	2540	771	1656	2910	941	1925	2600
Se	-	-	-	-	-	-	na
Ag	-	-	-	-	-	-	na
Na	15100	5140	10120	14900	4810	9855	48000
Tl	-	-	-	-	-	-	na
V	-	-	-	-	-	-	na
Zn	2090	41	1066	2090	46.1	1068	445

* Ref. SPRI, April '95
shaded data used as background
J^ - estimated value biased high

Table 7. Release of CERCLA Hazardous Substances to Downgradient Seeps of Alluvium Aquifer

	Average Concentration for Background Purposes in Alluvium Aquifer		S-1 Cliff Seep (Old Eagle Rock CG)		S-2 Capulin Channel Seep		S-3 Capulin River Seep: Lower		S-3 (Duplicate) Capulin River Seep: Lower		S-4 Capulin River Seep: Upper		S-5 Goathill Seep		S-7 Adit Seep	
	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered
Date Sampled			6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94	6/26/94
CLP ID#			SF5831	SF5832	SF5823	SF5827	SF5824	SF5828	SF5825	SF5829	SF5826	SF5830	SF5839	SF5842	SF5840	SF5843
Analyte (ug/L)																
Al	18322	18708	43100	43500	127000	120000	104000	108000	105000	105000	113000	114000	28500	28800	13700	17500
Sb	-	-	-	-	-	-	32.1	-	-	-	-	-	-	-	-	-
As	-	-	-	-	1.8J	1.0J	1.1J	-	1.1J	1.3J	2.1J	1J	-	-	-	-
Ba	16	14	12.8	13.6	8.1	7.9	9.8	12.2	13.6	13.9	8.2	8.1	20.1	25	62.5	58.1
Be	3	3	13.1	13.1	25.6	21.3	19.6	20.4	20	19.9	17.6	17.8	5.5	5.5	3.6	4.2
Cd	3	4	17.7J	23J	[illegible]	5.7	9.2J	12.1J	13.1J	15.2J	8.8J	-	11.1J	15.1J	13J	51.4J
Ca	97350	156000	79800	79500	224000	218000	199000	206000	201000	202000	216000	216000	275000	273000	206000	210000
Cr	3	4	2.9	-	3.3	3.8	4	3.4	3.8	3.9	6	3.9	-	4.8	-	-
Co	49	51	127	125	216	202	179	185	183	183	196	194	113	116	-	-
Cu	32	41	361	363	1010	916	741	776	755	763	1130	1140	233	234	22	37.9
Fe	30100	15237	47	146	4730	6010	7550	7860	7430	7900	14600	17500	27.9	602	18.4	59.1
Pb	1	3	2.1J	2.5J	4.0J	4.9J	4.4J	3.8J	5J	5.1J	3.6J	4.4J	3.4J	6.8J	1.7J	1.4J
Mg	30190	30695	44100	44000	63000	58100	50800	53000	51500	51900	55500	55900	104000	103000	80300	87000
Mn	2905	2914	19000	18900	19200	17000	14700	15200	14800	14900	15900	16000	4270	4250	6350	9460
Hg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	114	116	368	363	430	409	357	373	367	364	393	412	412	414	342	413
K	1656	2600	1650	1980	2770	3000	3290	3000	3210	3220	2460	3200	3270	3360	3150	3000
Se	-	-	na	na	na	na	na	na	na	na	na	na	1.3J	na	1.4J	1.5J
Ag	-	-	-	-	-	-	3.9	3.6	-	3.2	-	5.4	-	-	-	-
Na	10120	46000	10700	10500	26500	25500	22200	23000	22500	22300	27100	27100	32200	31600	22200	22400
Tl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	1066	1068	4560	4570	4890	4370	3790	3940	3840	3880	4230	4290	1650	1650	2470	3100

J - estimated value

Stippled data indicates concentrations which exceed 3 x background. Additional shading is for those metals representing CERCLA Hazardous Substances

* Ref. SPRI, April '95

Table 8. Release of CERCLA Hazardous Substances to Fractured Rock Aquifer at Molycorp Mine

	Highest Background Concentration*	Capulin Canyon (MW-3)**	Sugar Shack West (MW-7)**	Sugar Shack South (MW-10b)**	Sugar Shack South (MW-11)**	Sugar Shack South (MW-11 dup.)**	Cabin Spring**
CLP ID#		MFQ252	MFQ251	MFQ250	MFQ249	MFQ248	MFQ266
	F	F	F	F	F	F	UF
Analyte (ug/L)							
Al	1200	876	777000	6720	48800	45900	34500
As	<10	1.4J^	46.2J	nd	nd	nd	nd
Cd	19	nd	97.4	23.3J	30.3J	32.3	28.8
Cu	30	16.7	4220	111	832	787	424
Fe	39000	121J^	329000	227	nd	nd	nd
Mn	43600	28400	54700	7640	24900	23600	20100
Zn	25600	1190	8750	1120	4330	4090	3540

* ref.12, Table D4; ref. 30, Table 1.4 (highest reported value)
** ref. 64
F = filtered; UF = unfiltered
J - estimated value; ^ - datum biased high; nd - not detected
Shaded data indicate concentrations which exceed 3 x background.

Note: Only As, Cd and Cu represent CERCLA Hazardous Substances which have been released.

Table 9. Metal Concentrations and General Chemistry Parameters in Private Wells below the Tailings Ponds

Map Location Field Station	A CHANGE HOUSE WELL* W-1 (Background)		C DURAN WELL* W-5		D Duplicate W-5.5	E RAEL WELL* W-5**		N HERRERA WELL* W-6.5		MCL
CLP ID#	MFT996	MFT995	MFQ072	MFQ071	MFQ073	MFQ998	MFQ997	MFQ982	MFQ981	
	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	
Date Sampled	4/21/94		4/25/94			4/21/94		4/21/94		
Used for Drinking?			No			Yes		No		
Analyte (ug/L)										
Al	<34	108	nd	nd	nd	nd	55.8	nd	3210	50-200
Sb	<50	<50	nd	nd	nd	nd	nd	nd	nd	6
As	<1.0	<1.0	4.7	nd	nd	nd	nd	nd	1.4J	50
Ba	44.1	44.7	54	54.9	54.9	65.7	70	34.5	295	2000
Be	<1.0	<1.0	nd	nd	nd	nd	nd	nd	nd	4
Cd	<5.0	<5.0	nd	nd	nd	nd	nd	nd	nd	5
Ca	28200	28000	47400	46100	46000	80800	84000	231000	232000	
Cr	<9.0	<9.0	nd	nd	nd	nd	nd	nd	16.6	100
Co	<9.0	<9.0	nd	nd	nd	nd	nd	nd	nd	
Cu	<6.0J	<6.0J	nd	nd	nd	nd	nd	nd	7.2J	1300al
Fe	19	360	nd	1220	1420	13.5	849	184	17900	300
Pb	<1.0	2.5	nd	ND	3.1	nd	ND	8.5^J	2.5	15al
Mg	5260	5180	10400	10100	9970	14600	15600	44300	44400	
Mn	3.1	6.8	146	158	157	3.3	4.1	22	215	50a
Hg	<0.2	<0.2	nd	nd	nd	nd	nd	nd	nd	2
Ni	<11	<11	nd	nd	nd	nd	nd	nd	nd	100
K	<667	<667	867	877	873	<667	766	2840	2940	
Se	<2.0	2.6	nd	nd	nd	nd	nd	nd	nd	50
Ag	<5.0	<5.0	nd	nd	nd	nd	nd	nd	nd	50
Na	66300	66400	15800	15100	14900	26100	26900	71400	69900	
Tl	<2.0J	<2.0J	nd	nd	nd	nd	nd	nd	nd	2
V	<7.0	<7.0	nd	nd	nd	nd	nd	nd	7.2	
Zn	75.4J	75.1J	101J	150	165	206J	260J	nd	8.5J	5000a
	SF1386		SF1389		SF1390	SF1387		SF1385		
Gen. Chem. (ug/L)					(filtered)					
Alk	190000		103000		104000	112000		154000		
COD	ND		nd		nd	nd		nd		
TDS	292000		288000		277000	454000		1290000		500000a
TSS	ND		nd		nd	nd		nd		
NH3	ND		nd		nd	nd		nd		
Cl	<2000		6140		6140	8420		18300		250000a
NOX	400		260		280	400		1040		
TOC	5340J		nd		nd	2460J		5820J		
TPO4	120		nd		nd	120		170		
SO4	58000		72000		84000	209000		752000		250a

* ref. 64; ** Sample inadvertently labelled as W-5; nd - not detected; J - estimated value; ^ - value biased high

MCL - EPA Maximum Contaminant Level; a - aesthetic standard; l - irrigation standard

Stippled data are > 3 x background (or detected when undetected in background); additional shading for CERCLA Hazardous Substances

Table 10. Total Metal Concentrations in Selected Monitoring Wells near Tailings Ponds (ref. 64)

Map Location	A Change House Well (Background)	B MW-4	F MW-9a	K MW-3	L MW-1	M MW-1 (Duplicate)	G MW-2	H MW-C	I MW-7b	J MW-7c	MCL
Date Sampled	4/21/94	4/21/94	4/25/94	4/21/94	4/21/94	4/21/94	4/21/94	4/21/94	4/25/94	4/25/94	
pH (paper)	6.5	6.5	7.7*	6.5	6.5	6.5	6.5	6.5	7.6*	7.3*	
Conductivity (umhos)	328	1280	710	1120	1190	-	1340	1390	1180	1080	
Field ID#	W-1	W-2	W-4	W-6	W-7	W-7.5	W-8	W-9	W-11	W-12	
CLP ID#	MFT995	MFT969	MFQ076	MFQ979	MFT975	MFT977	MFT971	MFT973	MFQ074	MFQ069	
	UF	UF	UF	UF	UF	UF	UF	UF	UF	UF	
Analyte (ug/L)											
Al	108	36	78800	115	179	161	3690	94.3	53200J	2540J	50-200
Sb	<50	nd	nd	nd	nd	nd	nd	nd	nd	nd	6
As	<1J	nd	23.7	nd	nd	nd	nd	nd	15.2	nd	50
Ba	44.7	36.1	570	35.8	40	26.4	152	35	514	53.7	2000
Be	<1.0	nd	4.7	nd	nd	nd	nd	nd	4.6	nd	4
Cd	<5.0	nd	nd	nd	nd	nd	nd	5.1	nd	nd	5
Ca	28000	157000	197000	255000	224000	195000	222000	311000	274000	248000	
Cr	<9.0	nd	109	13.1	nd	nd	22	nd	88.1	nd	100
Co	<9.0	nd	32.1	nd	nd	nd	nd	nd	15.8	3.7	
Cu	<6J	nd	65.7	nd	nd	nd	nd	nd	38.9	7.8	1300al
Fe	360	643	69500	455	612	562	25200	170	38600	1900	300
Pb	2.5	2.4	65.6	1.5	nd	nd	4.4vJ	nd	44.9	5.3	15al
Mg	5180	31800	49900	46500	46000	40500	50000	53200	60500	45700	
Mn	6.8	43.5	1880	14.9	24.2	19	774	2420	743	37.3	50a
Hg	<0.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	2
Ni	<11	nd	82.2	nd	nd	nd	22.7	nd	65.3	nd	100
K	<667	nd	11000	1240	2770	2470	3150	3420	13800	3250	
Se	2.6	nd	nd	nd	nd	nd	nd	nd	nd	2.6	50
Ag	<5.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	50
Na	66400	65700	41100	67600	61100	52300	92100	87900	42300	39600	
Tl	<2J	nd	nd	nd	nd	nd	nd	nd	nd	nd	2
V	<7.0	nd	91.7	nd	nd	nd	nd	nd	48.8	3.9	
Zn	75.1J	nd	288	nd	nd	nd	nd	nd	177	16.4	5000a

* pH measured by laboratory

UF - unfiltered sample; nd - not detected; J - estimated value; v - value biased low

MCL - EPA Maximum Contaminant Level; a - aesthetic std.; l - irrigation std.

Stippled data are > 3 x background (or detected when undetected in background); additional shading for metals representing CERCLA hazardous substances

Table 11. Dissolved Metal Concentrations and General Chemistry Parameters in Selected Monitoring Wells near Tailings Ponds (ref. 64)

Map Location	A Change House Well (Background)	B MW-4	F MW-9a	K MW-3	L MW-1	M MW-1 (Duplicate)	G MW-2	H MW-C	I MW-7b	J MW-7c	MCL
Field ID#	W-1	W-2	W-4	W-6	W-7	W-7.5	W-8	W-9	W-11	W-12	
CLP ID #	MFT996 F	MFT970 F	MFQ077 F	MFQ980 F	MFT976 F	MFT978 F	MFT972 F	MFT974 F	MFQ075 F	MFQ070 F	
Analyte (ug/L)											
Al	<34	55.7	nd	nd	nd	48	128	135	nd	nd	50-200
Sb	<50	nd	nd	nd	nd	nd	nd	nd	nd	nd	6
As	<1J	nd	nd	nd	nd	nd	nd	nd	nd	3.6	50
Ba	44.1	36	92.7	31.4	26.2	ND	22.4	35.4	57.5	34	2000
Be	<1.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	4
Cd	<5.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	5
Ca	28200	158000	144000	243000	225000	222000	204000	307000	231000	237000	
Cr	<9.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	100
Co	<9.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	
Cu	<6J	nd	nd	nd	nd	nd	nd	nd	3.5	nd	1300al
Fe	19	31.3	ND	40.1	nd	nd	290	nd	nd	nd	300
Pb	<1.0	4.2	ND	8.3^J	nd	nd	nd	nd	nd	nd	15al
Mg	5260	30900	28100J	45000	46900	45800	45200	53800	43600	43400	
Mn	3.1	1.7	573J	1.9	3.2^J	3^J	550	2400	12	ND	50a
Hg	<0.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	2
Ni	<11	nd	nd	nd	nd	nd	nd	nd	nd	nd	100
K	<667	945	1420J	973	2630	2690	2900	3620	5770	2670	
Se	<2.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	50
Ag	<5.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	50
Na	66300	66600	40700J	65900	61300	59800	89200	89300	40600	38200	
Tl	<2J	nd	nd	nd	nd	nd	nd	nd	nd	nd	2
V	<7.0	nd	nd	nd	nd	nd	nd	nd	nd	2.6	
Zn	75.4J	nd	37J	nd	nd	nd	nd	nd	26.1J	7.8J	5000a
Gen. Chem.											
CLP ID#	SF1366	SF1368	SF1392	SF1384	SF1382	SF1383	SF1380	SF1381	SF1391	SF1388	
Alk	190000	188000	162000	179000	152000J	150000J	67500J	179000J	134000	131000	
COD	nd	nd	nd	nd	nd	7200	nd	5860	6600	nd	
TDS	292000	928000	81400	1340000	1162000	1313000	1314000	1690000	1330000	1280000	
TSS	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
NH3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
Cl	1000	8340	23500	18400	18300	18300	15600	17900	15200	16200	
NOX	400	320	360	370	710	710	nd	nd	330	340	
TOC	5340J	7370J	2150	5970J	3030J	4770J	1990J	5310J	2280	1390	
TPO4	120	120	nd	120	150	160	nd	120	nd	nd	
SO4	58000	521000	384000	779000	701000	749000	825000	1013000	818000	740000	

F - filtered sample; nd - not detected; J - estimated value; ^ - value biased high; v - value biased low
MCL - EPA Maximum Contaminant Level
Stippled data are > 3 x background (or detected when undetected in background); additional shading for metals representing CERCLA hazardous substances

Table 12. Total and Dissolved Metal Concentrations in Discharges below Tailings Ponds (ref. 64)

Map Location	A Change House Well (Background)		W Seep A		V Seep D		U Seep E		O Embargo Rd. Seep		R Outfall #002		X Warm Spring		Y Cold Spring		T Old Coldwater Spring Collection	
CLP ID#	MFT996 F	MFT995 UF	MFT955 F	MFT954 UF	MFT953 F	MFT952 UF	MFT952 F	MFT951 UF	MFT959 F	MFT958 UF	MFT963 F	MFT962 UF	MFT947 F	MFT946 UF	MFT949 F	MFT948 UF	MFT967 F	MFT966 UF
Analyte (ug/L)																		
Al	<34	108	nd	480	nd	658	50.3	66.9	119	248	148	135	35.5	nd	nd	nd	nd	44.5
Sb	<50	<50	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
As	<1J	<1J	1.2vJ	2.2vJ	1.3vJ	2.1vJ	2.1vJ	2.7vJ	nd	nd	nd	nd	3vJ	2.9vJ	1.6vJ	nd	nd	nd
Ba	44.1	44.7	66.4	73.8	27.7	41.8	28.1	27.6	13.5	16.2	27.1	27.3	20.1	18.3	45.1	44.8	52.6	54.3
Be	<1.0	<1.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cd	<5.0	<5.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ca	28200	28000	33600	33100	30800	30800	31200	31200	265000	269000	277000	291000	22200	21600	50900	50400	101000	105000
Cr	<9.0	<9.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Co	<9.0	<9.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cu	<6J	<6J	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fe	19	360	nd	494	nd	900	nd	nd	nd	nd	nd	19.9	nd	nd	nd	nd	nd	nd
Pb	<1.0	2.5	nd	5	nd	2.7	nd	nd	1	1.7	nd	nd	nd	nd	nd	nd	nd	nd
Mg	5260	5180	10800	10700	9770	10000	9960	9850	45400	47200	46400	47400	6830	6730	8790	9120	16700	17400
Mn	3.1	6.8	3.7vJ	8.6	nd	56.8	2.8vJ	4.8vJ	569	650	1820	1860	1vJ	nd	nd	nd	nd	nd
Hg	<0.2	<0.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ni	<11	<11	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
K	<667	<667	3670	3490	2740	3140	2960	2690	4140	4350	3520	4010	2390	2280	1120	1210	1860	2130
Se	<2.0	2.6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ag	<5.0	<5.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Na	66300	66400	41200	41100	33000	33800	31800	31700	90100	92000	91700	91600	24900	24300	25100	24700	46000	48000
Tl	<2J	<2J	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
V	<7.0	<7.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Zn	75.4J	75.1J	nd	nd	nd	11.8	nd	nd	nd	8.3	nd	nd	nd	nd	nd	nd	nd	nd
Gen. Chem.																		
	SF1388		SF1373		SF1371		SF1372		SF1375		SF1377		SF1369		SF1370		SF1379	
Alk	190000		92900J		80200J		80200J		160000		158000J		84400J		158000J		184000J	
COD	nd		nd		nd		nd		nd		nd		nd		nd		nd	
TDS	292000		320000		287000		281000		1633000		1580000		199000		266000		563000	
TSS	nd		nd		nd		nd		nd		nd		nd		nd		nd	
NH3	nd		nd		nd		nd		nd		nd		nd		nd		nd	
Cl	<2000		12000		10300		9810		16000		15600		8880		6080		9530	
NOX	400		210		300		390		nd		nd		350		630		370	
TOC	5340J		1760J		1090J		nd		3430J		2560J		nd		1660J		2780J	
TPO4	120		170		170		170		130		160		160		100		nd	
SO4	58000		127000		68000		105000		1005000		973000		54000		67000		254000	

F - filtered sample; UF - unfiltered sample
nd - not detected; J - estimated value; v - value biased low
Stippled data are > 3 x background (or detected when undetected in background); additional shading
for metals representing CERCLA hazardous substances

Table 13. Ratio of Metal Concentrations in Leachate or Drainage from Mine Dumps to Hydrothermal Scars

Analyte (ug/L)	Average Mine Leachate Concentration (# of Samples=2)	Average Scar Leachate Concentration (Goathill & Hanson Crk) (# of Samples=2)	Ratio Mine Dump/Hydrothermal Scar
Al	1245000	162850	7.6
Sb	ND	24	0.0
As	51	11	4.8
Ba	na	na	na
Be	439	57	7.7
Cd	490	11	43.8
Ca	383500	234500	1.6
Cr	320	11	29.0
Co	2910	286	10.2
Cu	12150	2445	5.0
Fe	663500	484435	1.4
Pb	10	4	2.7
Mg	952500	57900	16.5
Mn	603500	41905	14.4
Hg	ND	0.2	na
Ni	6550	559	11.7
K	801	3605	0.2
Se	7	8	1.0
Ag	80	35	2.3
Na	25150	8915	2.8
Tl	3	3	1.1
V	8	16	0.5
Zn	133000	8835	15.1
Mo	34	16	2.1

ND - not detected; na - not available or not calculable
Note: one half detection limit was used in calculating average when detected in the other sample.

Table 14. Ratio of Metal Concentrations in Leachate from Mine Waste Dumps and Hydrothermal Scars*

Analyte (mg/L)	Mine Waste Mean (n=9)	Scar Mean (n=8)	Ratio
Al	471	230	2.1
Cd	0.14	0.03	5.4
Cr	1.24	0.48	2.6
Co	0.16	0.08	2.1
Cu	3.89	2.19	1.8
Fe	230	317	0.7
Mn	210	31	6.7
Ni	2.54	1.20	2.1
Pb	0.18	0.10	1.8
Zn	36.0	7.2	5.0

* ref. SRK, 1995, Table 1.2

Table 15. Total Metal Concentrations in Surface Water near Molycorp Mine

Map Location	18 Red River above Hanson Creek	17 Red River below Hanson Creek	16 Red River above Molycorp (Background)	12 Red River below (30') Adit Seep	11 Red River above Columbine Creek	10 Columbine Creek	9 Red River below Columbine Creek	7 Red River @ Goathill Gulch Seep	6 Red River above Capulin Seeps	5 Red River between Capulin Seeps	3 Red River below (20') Capulin Seeps	3 (duplicate) Red River below (20') Capulin Seeps	2 Red River above Pipeline Crossing
Station	RR-12	RR-11	RR-10	RR-9	RR-8	RR-7	RR-6	RR-5	RR-4a	RR-4	RR-3	RR-2	RR-1
CLP ID#	MFQ393	MFQ392	MFQ272	MFQ271	MFQ243	MFQ199	MFQ198	MFQ197	MFQ196	MFQ195	MFQ194	MFQ193	MFQ192
Date Sampled	11/8/94	.11/8/94	11/8/94	11/8/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94
Temp (C)	na	4.5	5	5	6	4.5	5.5	6	4.5	6	6	6	7
pH	6	6	6	6.5	6.5	7	7	7	6.5	6.5	7	6.5	6.5
Cond. (umhos)	na	160	178	190	195	80	172	230	222	235	250	250	261
	UF	UF	UF	UF	UF	UF	UF	UF	UF	UF	UF	UF	UF
Analyte (ug/L)													
Al	347	612	1070	1290	1060	49.7	856	1270	1540	1690	2050	2050	2590
Sb	-	-	-	-	-	-	-	-	-	-	-	-	-
As	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	40.9	40.5	41.1	39.6	36.5	41.8	37.4	37.1	36.7	36.1	36.5	36.7	36.9
Be	0.35	0.35	0.34	-	0.35		0.45	0.59	0.45	0.54	0.45	0.55	0.7
Cd	-	-	-	-			-	-	-	-	-	-	-
Ca	33300	34200	36900	40700	39800	23000	36600	44600	46000	46100	46900	46600	47000
Cr	-	-	-	-		-	-	-	-	-	-	-	-
Co	-	-	-	-		-	-	6.8	-	-	-	7.9	7.4
Cu	13.1	11.2	14.3	15.9	15.6		10	16.2	21.8	20.5	24.3	26.1	29.8
Fe	294	376	394	557	320	49.7	263	265	269	279	386	355	407
Pb	-	-	1.1	-	0.93	-	-	1.1	1	-	-	-	1.3
Mg	7090	7240	8220	9200	9070	2290	7670	10100	10500	10500	10700	10600	11000
Mn	109	138	208	299	267	-	208	495	531	553	607	603	851
Hg	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	-	-	-	-	-	-	-	-	-	18.7		23	-
K	1200	1140	1030	999	1210	810	983	1320	-	1090	668	1130	971
Se	-	-	-	-	-	-	-	-	873	-	-	-	-
Ag	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	5260	5120	5430	5230	5530	21000	4830	5250	5620	5610	5660	5550	5490
Tl	-	-	-	-	-	-	-	-	-	-	-	-	-
V	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	32.1	48.7	60.9	92.8	75.3	3.3	56.5	123	132	136	153	149	206

- not detected

Shaded data is > 3 x background; only Zn is a listed CERCLA hazardous substance

Table 16. Dissolved Metal Concentrationsand General Chemistry Parameters in Surface Water near Molycorp Mine

Map Location	18 Red River above Hanson Creek	17 Red River below Hanson Creek	16 Red River above Molycorp (Background)	12 Red River below (30') Adit Seep	11 Red River above Columbine Creek	10 Columbine Creek	9 Red River below Columbine Creek	7 Red River @ Goathill Gulch Seep	6 Red River above Capulin Seeps	5 Red River between Capulin Seeps	3 Red River below (20') Capulin Seeps	3 (duplicate) Red River below (20') Capulin Seeps	2 Red River above Pipeline Crossing
Station	RR-12	RR-11	RR-10	RR-9	RR-8	RR-7	RR-6	RR-5	RR-4a	RR-4	RR-3	RR-2	RR-1
CLP ID#	MFQ397	MFQ396	MFQ395	MFQ394	MFQ253	MFQ254	MFQ255	MFQ256	MFQ257	MFQ258	MFQ259	MFQ260	MFQ261
	F	F	F	F	F	F	F	F	F	F	F	F	F
Analyte (ug/L)													
Al	115	48.4	115	51.5	-	-	-	-	-	-	-	-	-
Sb	-	-	-	-	-	-	-	-	-	-	-	-	-
As	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	44.2	40.2	36.7	33.6	37	43.4	37	36.1	35.4	35	36.3	35.2	36.5
Be		0.3	-	0.3	-	-	-	-	-	-	-	-	-
Cd	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca	33400	34300	36900	38800	42200	24600	38400	46500	48600	48800	49200	49000	49900
Cr	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	-	-	-	-	-	-	-	-	-	5.1	-	-	6.7
Cu	6.8	3.7	3.7	4.4	4.3	-	3.1	3.7	3.1	5.6	4.9	6.2	6.8
Fe	29.5	12.7	19.3	29	-	-	-	211	-	-	-	-	-
Pb	-	-	1.9	-	-	-	-	-	-	-	-	-	-
Mg	7050	7260	8140	8760	9540	2540	8080	10800	11200	11100	11200	11200	11600
Mn	108	130	195	250	275	-	216	513	550	573	630	628	678
Hg	-	-	-	-	0.22J^	0.2J^	-	-	-	-	-	-	-
Ni	-	-	-	-	-	-	-	-	22.1	19.5	28.7	20.4	33
K	868	775	1320	1220	720	697	1170	613	1020	1110	1080	1190	1070
Se	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	5400	5270	5640	5750	5250	2160	4660	5290	5560	5480	5480	5410	5600
Tl	-	-	-	-	-	-	-	-	-	1.4	-	-	-
V	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	22.1	28.8	29.9	62	49.4	6.6	45.1	103	103	110	125	126	159
Gen. Chem.													
(mg/L)*													
Ca	41	42	45	48	49	26	40	49	51	50	52	53	54
Mg	7	7	8	9	9	3	8	11	11	11	12	12	12
K	4	4	4	4	4	4	4	4	4	4	4	4	4
Na	5	5	6	6	6	-	5	6	6	6	6	6	6
Hardness	131	134	145	154	157	74	135	166	175	171	176	179	184
Alkalinity	64	62	58	56	56	64	58	52	50	49	47	46	42
HCO3	78	76	72	69	68	78	71	64	61	60	57	57	52
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-
SO4	55	59	74	88	89	10	71	106	112	114	117	118	122
TDS	200	206	220	246	234	98	224	256	262	266	282	284	283
TSS	4	6	9	9	10	-	5	9	8	10	10	13	8

F = filtered sample

- not detected; J^ - estimated value which is biased high

* New Mexico State Laboratory Division data

Shaded data is > 3 x background of which only Zn is a listed CERCLA hazardous substance

Table 17. Metal Concentrations and General Chemistry Parameters in the Red River near Molycorp Mine: 6/26/94

	Red River above Hanson Creek		Red River below Columbine Creek		Red River at USFS Ranger Station	
Date Sampled CLP ID#	6/26/94 SF5850 F	6/26/94 SF5852 UF	6/26/94 SF5841 F	6/26/94 SF5844 UF	6/26/94 SF5861 F	6/26/94 SF5862 UF
Analyte (ug/L)						
Al	73.3	286	84.1	284J^	-	1360
Sb	-	-	31.7	-	-	-
As	-	-	-	na	na	na
Ba	25.6	29.4	32.3	38J	26.9J	39.8J
Be	-	-	-	-	-	-
Cd	-	-	-	-	-	-
Ca	21500	21200	21200	21700J	29000J	29800J
Cr	-	-	-	-	-	-
Co	-	-	-	-	5.4J	5.9J
Cu	-	-	-	-	-	-
Fe	40.3	331	15.3	-	-	-
Pb	-	-	-	2.5J	na	2J
Mg	3520	3510	2850	2960	5890	6210
Mn	29.4	37.1	33.3	55.8	369	407
Hg	0.2	-	-	-	-	0.22
Ni	-	-	-	-	-	-
K	796	-	-	-	-	-
Se	na	na	na	-	-	-
Ag	-	-	-	-	-	-
Na	2210	2070	1900	-	-	-
Tl	-	-	-	-	-	-
V	-	-	-	-	-	-
Zn	18.3	10.1	10.1	25.7	62.8	95.2
Mo	-	-	-	-	-	-
Gen. Chem.						
	SF5854		SF5848		SF5863	
Alk	57000		63300		45400	
COD	-		-		-	
TDS	102000		92000		156000	
TSS	10000		12000		14000	
NH3	-		-		-	
Cl	-		-		-	
NOX	150		100		160	
TOC	2650		2550		2700	
TPO4	240		140		-	
SO4	21000		12600		53700	

Shaded data are > 3 x concentration below Columbine Creek

- = not detected

na = not available (data unusable)

J = estimated value

^ = value biased high

Table 18. Metal Concentrations in Sediments from the Red River near Molycorp Mine Area

Map Location	L Red River above Hanson Crk.	K Red River below Hanson Crk.	J Red River above Molycorp Property (Background)	I Red River below (30') Adit Seep	H Red River above Columbine Creek	G Columbine Creek	F Red River below Columbine Creek	E Red River below Goathill Seep	D Red River above Capulin Seeps	C Red River between per and low Capulin Seeps	B Red River below (20') Capulin Seeps (duplicate)	B Red River below (20') Capulin Seeps	A Red River above Pipeline Crossing
Date Sampled:	11/8/94	11/8/94	11/8/94	11/8/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94	11/7/94
Field ID #	S-12	S-11	S-10	S-9	S-8	S-7	S-6	S-5	S-4a	S-4	S-3	S-2	S-1
CLP ID#	MFQ696	MFQ695	MFQ399	MFQ398	MFQ191	MFQ190	MFQ189	MFQ187	MFQ188	MFQ186	MFQ185	MFQ184	MFQ182
Analyte (mg/kg)													
Al	15000	4510	5250	12200	12600	10500	10500	10900	13900	24200	19500	16000	12600
Sb	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
As	10Jv	5.6Jv	4Jv	8.5Jv	11.2Jv	1.2Jv	8.4Jv	6.1Jv	7.4Jv	9.2Jv	8.8Jv	6.1Jv	11Jv
Ba	787	262	439	694	601	78.5	567	406	537	578	569	508	499
Be	1.1	0.34	0.43	1.3	1.2	0.46	1.1	1.1	2.1	2.4	1.8	1.5	1.8
Cd	nd	nd	nd	nd	nd	nd	nd	nd	2.1	nd	nd	nd	nd
Ca	3690	1190	1470	2340	2900	2490	3020	2210	3230	1860	2150	1980	2990
Cr	23.5	6.5	8.8	22.1	20.5	12.5	16.8	20.3	18.7	22.3	23.9	20.7	18.5
Co	12.9	4	6.9	13.2	14.1	13.1	12.7	13.3	19	13.5	14.6	12.2	21.8
Cu	142	22	25.1	135	78.9	21.2	71.1	104	126	152	116	98.3	116
Fe	45800	14800	17600	40600	38400	26700	33600	31300	33700	47600	41800	38000	34400
Pb	163	21.4	29.3	94.1	130	118	106	91.1	97.5	144	119	102	132
Mg	6110	1700	2210	5310	5300	7420	4560	5090	4640	5400	5680	4970	4670
Mn	636	115	165	534	538	701	550	466	1080	553	501	468	1310
Hg	nd	nd	nd	nd	nd	0.13	nd	nd	0.23	nd	nd	nd	nd
Ni	23.2	8.6	13.9	24	31.2	7.4	30.9	18.1	59.2	29.4	32.5	27.3	53.6
K	5290	1980	1700	3640	3980	1030	3130	2540	3080	4330	3960	3390	2890
Se	1.8	0.44	nd	1.1	1.6	nd	1.1	1.4	1.1	1.1	1.3	0.94	1.3
Ag	3.3	nd	nd	nd	nd	1.9	1.9	2.3	2.5	nd	nd	1.8	1.5
Na	292	76.5	122	297	277	54.4	238	245	254	326	290	241	232
Tl	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.69	nd	nd	nd
V	24.8	6.5	7.9	20.5	20.6	43.6	16.8	22.2	18.9	21.2	24.7	21.6	18.6
Zn	274	44.5	93.9	190	237	136	221	182	548	298	250	220	469

nd - not detected; Jv - estimated value is biased low
Stippled data are > 3 x background concentration (or detected when undetected at background location)
Additional shading for those metals representing CERCLA hazardous substances

Table 19. Metal Concentrations in Selected Seeps and Surface Water Bodies near the Tailings Ponds

Map Location	18 Embargo Rd. Seep		19 Irrigation Ditch above Seep		20 Irrigation Ditch below Seep		21 #002 OUTFALL		22 50' W of 002 OUTFALL	
CLP ID#	MFT959 F	MFT958 UF	MFT961 F	MFT960 UF	MFT957 F	MFT956 UF	MFT963 F	MFT962 UF	MFT965 F	MFT964 UF
Analyte (ug/L)										
Al	119	248	111	971	136	1050	148	135	40	149
Sb	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND
Ba	13.5	16.2	27.4	32	26	37.7	27.1	27.3	57.5	60.8
Be	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ca	265000	269000	49100	46800	45700	52900	277000	291000	123000	119000
Cr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Co	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cu	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fe	ND	ND	109	963	116	1160	18.7UC	19.9	33.4	251
Pb	1	1.7	ND	ND	ND	1.4vJ	ND	ND	ND	ND
Mg	45400	47200	9190	8970	8500	9910	46400	47400	20700	208000
Mn	569	650	8.8vJ	36.4	15.8	65	1820	1860	11	10.9vJ
Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K	4140	4350	863	1110	791	1390	3520	4010	1060	1370
Se	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ag	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Na	90100	92000	15400	ND	14700	ND	91700	91600	48000	46700
Tl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zn	ND	8.3	ND	ND	ND	ND	ND	ND	ND	ND
Gen. Chem.										
(ug/L)										
CLP ID#	SF1375		SF1376		SF1374		SF1377		SF1378	
Alk	160000		71800J		71800J		158000J		167000J	
COD	ND		8410		6840		ND		ND	
TDS	1633000		273000		304000		1580000		679000	
TSS	ND		ND		ND		ND		ND	
NH3	ND		ND		ND		ND		ND	
Cl	16000		3630		3860		15600		12300	
NOX	ND		130		130		ND		ND	
TOC	3430J		3000J		2890J		2560J		2840J	
TPO4	130		ND		110		160		100	
SO4	1005000		121000		127000		973000		290000	

F - filtered sample; UF - unfiltered sample
ND - not detected
J - estimated value; v - value is biased low

Table 20. Loading of Sulfate and Selected Metals into the Red River by Stream Segment during ESI Sampling

Location:	Flow (cfs)*	SO4 conc.	SO4 gain	Mass gain	% of total gain	
		mg/l	(flow x conc)			
Abv. Molycorp Mill	18	74	1332	499.8	31.8	Moly Mill to Columbine Ck.
Below Columbine Crk.	25.8	71	1832	1030.2	65.6	Columbine to Goathill Gulch
Goathill Gulch	27	106	2862	418.4	26.6	Goathill to Blw Capulin Cyn
Blw Capulin Canyon	27.8	118	3280	196.6	12.5	Blw Capulin Cyn to Eagle Rk CG
Eagle Rock CG	28.5	122	3477			
FS Ranger St.	29					
			Total Gain =	2145		
Location:	Flow (cfs)	Al conc.	Al gain	Mass gain	% of total gain	
		mg/l	(flow x conc)			
Abv. Molycorp Mill	18	1.07	19.3	2.8	5.2	Moly Mill to Columbine Ck.
Below Columbine Crk.	25.8	0.856	22.1	12.2	22.4	Columbine to Goathill Gulch
Goathill Gulch	27	1.27	34.3	22.7	41.6	Goathill to Blw Capulin Cyn
Blw Capulin Canyon	27.8	2.05	57.0	16.8	30.8	Blw Capulin Cyn to Eagle Rk CG
Eagle Rock CG	28.5	2.59	73.8			
FS Ranger St.	29					
			Total Gain =	54.6		
Location:	Flow (cfs)	Mn conc.	Mn gain	Mass gain	% of total gain	
		mg/l	(flow x conc)			
Abv. Molycorp Mill	18	0.195	3.5	1.9	8.9	Moly Mill to Columbine Ck.
Below Columbine Crk.	25.8	0.208	5.4	8.0	38.6	Columbine to Goathill Gulch
Goathill Gulch	27	0.495	13.4	3.4	16.4	Goathill to Blw Capulin Cyn
Blw Capulin Canyon	27.8	0.603	16.8	7.5	36.1	Blw Capulin Cyn to Eagle Rk CG
Eagle Rock CG	28.5	0.851	24.3			
FS Ranger St.	29					
			Total Gain =	20.7		
Location:	Flow (cfs)	Zn conc.	Zn gain	Mass gain	% of total gain	
		mg/l	(flow x conc)			
Abv. Molycorp Mill	18	0.061	1.098	0.4	7.9	Moly Mill to Columbine Ck.
Below Columbine Crk.	25.8	0.057	1.4706	1.9	39.0	Columbine to Goathill Gulch
Goathill Gulch	27	0.123	3.321	0.9	19.7	Goathill to Blw Capulin Cyn
Blw Capulin Canyon	27.8	0.153	4.2534	1.6	33.5	Blw Capulin Cyn to Eagle Rk CG
Eagle Rock CG	28.5	0.205	5.8425			
FS Ranger St.	29					
			Total Gain =	4.7		

* Flow was estimated by applying flow rates from Vail 1993 to gauged flow of 29 cfs.

Shaded data represents reach of Red River demonstrating highest gain

Table 21. Sulfate Gain Observed in Red River between Molycorp Property and USFS Ranger Station

Nov. 7, 1994	flow (cfs)	SO4 conc. (mg/l)	SO4 gain	Gain w/in stream reach	% of total gain	
Blw Hanson Crk	13.9	59	820	246	13.5	Hanson Crk to Moly Mill
Abv Moly Mill	14.4	74	1066	314	17.3	Moly Mill to Columbine Ck.
Abv Col. Crk	15.5	89	1380	794	43.7	Columbine to Goathill G.
Goathill Gulch	20.5	106	2173	317	17.5	Goathill to Blw Capulin Cyn
Blw Cap. Cyn	21.1	118	2490	145	8.0	Blw Capulin Cyn to Eagle Rk C
Eagle Rock CG	21.6	122	2635			
FS Ranger St.	25		0			
				1815		

Feb. 16, 1993	flow (cfs)	SO4 conc. (mg/l)	SO4 gain	Gain w/in stream reach	% of total gain	
Blw Hanson Crk	13.9	33.81	470	180	7.9	Hanson Crk to Moly Mill
Abv Moly Mill	14.4	45.17	650	234	10.2	Moly Mill to Columbine Ck.
Abv Col. Crk	15.5	57.06	884	1276	55.5	Columbine to Goathill G.
Goathill Gulch	20.5	105.38	2160	206	9.0	Goathill to Blw Capulin Cyn
Blw Cap. Cyn	21.1	112.13	2366	401	17.5	Blw Capulin Cyn to Ranger St.
FS Ranger St.	22	125.77	2767			
				2297		

Oct. 22, 1992	flow (cfs)	SO4 conc. (mg/l)	SO4 gain	Gain w/in stream reach	% of total gain	
Blw Hanson Crk	15.8	66	1043	326	11.7	Hanson Crk to Moly Mill
Abv Moly Mill	16.1	85	1369	638	22.9	Moly Mill to Columbine Ck.
Abv Col. Crk	17.6	114	2006	1069	38.4	Columbine to Goathill G.
Goathill Gulch	23.3	132	3076	284	10.2	Goathill to Blw Capulin Cyn
Blw Cap. Cyn	24	140	3360	465	16.7	Blw Capulin Cyn to Ranger St.
FS Ranger St.	25	153	3825			

Nov. 29, 1988	flow (cfs)	SO4 conc. (mg/l)	SO4 gain	Gain w/in stream reach	% of total gain	
Blw Hanson Crk	10.7	46	492	216	11.8	Hanson Crk to Moly Mill
Abv Moly Mill	10.9	65	709	468	25.5	Moly Mill to Columbine Ck.
Abv Col. Crk	12	98	1176	499	27.2	Columbine to Goathill G.
Goathill Gulch	15.8	106	1675	297	16.2	Goathill to Blw Capulin Cyn
Blw Cap. Cyn	16.3	121	1972	357	19.4	Blw Capulin Cyn to Ranger St.
FS Ranger St.	17	137	2329			
				1837		

Nov. 25, 1988	flow (cfs)	SO4 conc. (mg/l)	SO4 gain	Gain w/in stream reach	% of total gain	
RR@Elephant CG	16	46	736	564	16.7	Hanson Crk to Moly Mill
Abv Moly Mill	20	65	1300	562	16.7	Moly Mill to Columbine Ck.
Abv Col. Crk	19	98	1862	1000	29.6	Columbine to Goathill G.
Goathill Gulch	27	106	2862	647	19.2	Goathill to Blw Capulin Cyn
Blw Cap. Cyn	29	121	3509	601	17.8	Blw Capulin Cyn to Ranger St.
FS Ranger St.	30	137	4110			
				3374		

Shaded data represent reach of Red River demonstrating highest SO4 gain

Table 22. Relative Percent Difference between Duplicate Samples

	Sediment	Surface Water	
Analyte		filtered	unfiltered
Al	19.7	-	
Sb	-	-	
As	36.2	-	
Ba	11.3	3.1	0.5
Be	18.2	-	20.0
Cd	-	-	-
Ca	8.2	0.4	0.6
Cr	14.3	-	-
Co	17.9	-	200.0
Cu	16.5	23.4	7.1
Fe	9.5	-	8.4
Pb	15.4	-	-
Mg	13.3	0.0	0.9
Mn	6.8	0.3	0.7
Hg	-	-	-
Ni	17.4	33.8	-
K	15.5	9.7	51.4
Se	32.1	-	-
Ag	-	-	-
Na	18.5	1.3	2.0
Tl	-	-	-
V	13.4	-	-
Zn	12.8	0.8	2.6

- cannot be calculated due to undetected concentrations

Table 23. Metal Concentrations in Residentials Areas near Tailings Ponds

Map Location CLP ID# Soil Type* Analyte (mg/kg)	Average Metal Conc. in Tailings (N=8)	Average Metal Conc. in Background Soil (N=3) Sedillo Soil Type*	Ratio of Conc. (tailings/bckgrd)	17 Change House MFT934 Sedillo	15 Feliciano Rael MFT937 Sedillo	14 Roger Herrera MFT938 Sedillo	16 Cecil Clines MFT939 Sedillo	Benchmark (ref. 2)
Al	8050	2887	2.8	8290	7140	7070	8300	
Sb	0	2.4	0.0	ND	ND	ND	ND	
As	0.78	0.78	1.0	1.9	1.5	1.3	1.4	
Ba	87	48.7	1.8	157	108	156	121	41000
Be	1	0.18	5.0	0.63	0.56	0.58	0.49	0.14**
Cd	0.2	ND	na	ND	ND	ND	ND	
Ca	16250	1111	14.6	5360.0	2490.0	8670.0	3060	na
Cr	40	3.5	11.5	12.8	16.4	14	17.5	2900
Co	10	3.0	3.4	7.3	9.1	7.1	8.7	na
Cu	188	6.3	29.9	31.7	20.1	20.3	22.7	na
Fe	16693	7177	2.3	11700	14200	113000	15400	
Pb	58	12.6	4.6	33.7	17.3	21.7	15.7	
Mg	7743	1051	7.4	3520.0	3350.0	3710.0	3830.0	na
Mn	471	298	1.6	527	541	548	469	
Hg	ND	ND	na	ND	ND	ND	ND	
Ni	30	3.8	7.9	13.6	15.5	15.4	15.6	12000
K	4761	1049	4.5	1650	1650	2960	1650	
Se	ND	ND	na	ND	ND	ND	ND	
Ag	ND	ND	na	ND	ND	ND	ND	
Na	137	38.5	3.6	56.7	49.4	97.8	89.9	
Tl	0.5	ND	na	ND	ND	ND	ND	
V	35	7.9	4.5	18.6	19.3	14.8	21.9	
Zn	121	33.5	3.6	63.7J	57.8J	80.8J	52.4J	

* ref. SCS 1982
** Cancer Risk Screening Concentration
Shaded data are > 3 x background concentrations; J = estimated value
ND - not detected; na - not available or calculable

Table 24. Metal Concentrations in Residentials Areas near Tailings Ponds

Map Location	Average Metal Concentration in Tailings	23 1/4-mile north of Questa Jr. High (initial background)	24 Cerro Rd. # 1 (background)	25 Cerro Rd. # 2 (background)	26 Cerro Rd. # 2 (duplicate)	Average Background Concentration	Ratio of Concentrations (tailings/bckgrd)	22 Questa Jr. High School-2	20 Questa Jr. High School-3	21 Questa Jr. High School-3 (duplicate)	18 Arch Trujillo	19 Romolo Martinez
CLP ID#	(N=8)	MFT945	MFQ-082	MFQ-083	MFQ-084			MFT931	MFT932	MFT933	MFT935	MFT936
Soil Type*		Silva	Silva	Silva	Silva	Silva Soil Type		Silva	Silva	Silva	Silva	Silva
Analyte (mg/kg)												
Al	8050	13600	9790	8950	13700	11510	0.7	12300	8000	10900	8710	8650
Sb	ND	ND	ND	ND	ND	ND	na	ND	ND	ND	ND	ND
As	0.78	ND	4.7	4.4	5.5	3.7	0.2	2.3	2	ND	2.5	1.5
Ba	87	187	156	159	185	172	0.5	218	196	195	167	192
Be	1	0.75	0.72	0.79	0.97	0.81	1.1	0.88	0.67	0.69	0.62	0.62
Cd	0.2	0.98	ND	0.57	0.65	0.55	0.4	ND	ND	1.2	ND	ND
Ca	16250	4670	2570	2280	2580	3025	5.4	9970	7680	7010	13700	14000
Cr	40	13.2	13.1	13.7	17.7	14.4	2.8	11.8	8.2	11.5	9	14.5
Co	10	7.1	10	12	14.3	10.9	1.0	8.7	7.7	6.7	6.6	7.8
Cu	188	14.4	17.4	24.3	29.2	21.3	8.8	19.5	16.9	16	16.4	30.2
Fe	16693	17200	17500	19400	25000	19775	0.8	15000	10700	14300	13200	12500
Pb	58	16.2vJ	20.3	23.5	24.9	21.2	2.7	18.7	15.8	3.3vJ	16.4	48.4
Mg	7743	4100	2550	2590	3220	3115	2.5	4100	3100	3700	3980	4280
Mn	471	493	655	789	904	710	0.7	589	504	518	457	542
Hg	ND	ND	ND	ND	ND	ND	na	ND	ND	ND	ND	ND
Ni	30	12.4	11	11.6	14.3	12.3	2.4	12.6	9.2	11.2	11.5	14.3
K	4761	2650	1850	2230	2910	2410	2.0	3040	1700	2070	2090	2630
Se	ND	0.21J	1.1J	0.92	1.4J	0.23	0.0	ND	ND	ND	ND	ND
Ag	ND	ND	ND	ND	ND	ND	na	ND	ND	ND	ND	0.81
Na	137	86.9	86.2	79.6	105	89.4	1.5	104	61.6	73.5	93.7	85.6
Tl	ND	ND	ND	ND	ND	ND	na	ND	ND	ND	ND	ND
V	35	24.8	36.1	33	41.3	33.8	1.0	19.8	19.9	22.4	24.5	21
Zn	121	49.3	48.5	65.3	85.3	62.1	1.9	60.7J	42.1J	44.1	52.6J	2020

* ref. SCS 1982

J = estimated value; v - value biased low

ND = not detected; na = not available or calculable

Note: Shaded datum is > 3 x background but also > average concentration in tailings

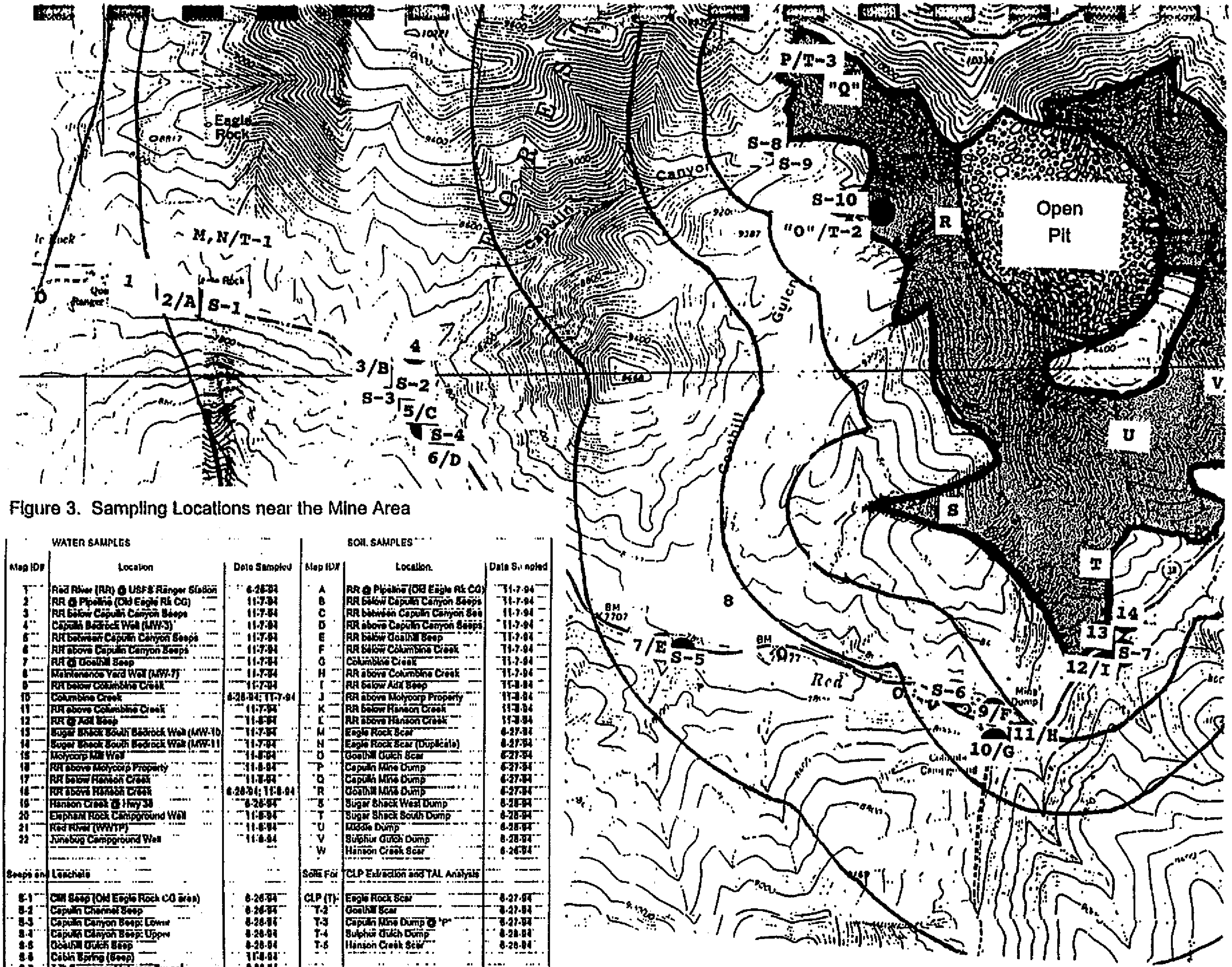


Figure 3. Sampling Locations near the Mine Area

WATER SAMPLES		
Map ID#	Location	Date Sampled
1	Red River (RR) @ USFS Ranger Station	6-26-94
2	RR @ Pipeline (Old Eagle Rk CG)	11-7-94
3	RR below Capulin Canyon Seeps	11-7-94
4	Capulin Bedrock Well (MW-3)	11-7-94
5	RR between Capulin Canyon Seeps	11-7-94
6	RR above Capulin Canyon Seeps	11-7-94
7	RR @ Goathill Seep	11-7-94
8	Maintenance Yard Well (MW-7)	11-7-94
9	RR below Columbine Creek	11-7-94
10	Columbine Creek	6-26-94; 11-7-94
11	RR above Columbine Creek	11-7-94
12	RR @ Adit Seep	11-8-94
13	Sugar Shack South Bedrock Well (MW-10	11-7-94
14	Sugar Shack South Bedrock Well (MW-11	11-7-94
15	Molycorp Mill Well	11-8-94
16	RR above Molycorp Property	11-8-94
17	RR below Hanson Creek	11-8-94
18	RR above Hanson Creek	6-26-94; 11-8-94
19	Hanson Creek @ Hwy 38	6-26-94
20	Elephant Rock Campground Well	11-8-94
21	Red River (WWTP)	11-8-94
22	Junebug Campground Well	11-8-94
Seeps and	Leachate	
S-1	Cliff Seep (Old Eagle Rock CG area)	6-26-94
S-2	Capulin Channel Seep	6-26-94
S-3	Capulin Canyon Seep: Lower	6-26-94
S-4	Capulin Canyon Seep: Upper	6-26-94
S-5	Goathill Gulch Seep	6-26-94
S-6	Cabin Spring (Seep)	11-8-94
S-7	Adit Seep near Molycorp Tunnel	6-28-94
S-8	Capulin Dump Collection: Upper	6-27-94
S-9	Capulin Dump Collection: Middle	6-27-94
S-10	Goathill Gulch Scar	6-27-94
S-11	Hanson Creek Scar	6-28-94

SOIL SAMPLES		
Map ID#	Location	Date Sampled
A	RR @ Pipeline (Old Eagle Rk CG)	11-7-94
B	RR below Capulin Canyon Seeps	11-7-94
C	RR between Capulin Canyon See	11-7-94
D	RR above Capulin Canyon Seeps	11-7-94
E	RR below Goathill Seep	11-7-94
F	RR below Columbine Creek	11-7-94
G	Columbine Creek	11-7-94
H	RR above Columbine Creek	11-7-94
I	RR below Adit Seep	11-8-94
J	RR above Molycorp Property	11-8-94
K	RR below Hanson Creek	11-8-94
L	RR above Hanson Creek	11-8-94
M	Eagle Rock Scar	6-27-94
N	Eagle Rock Scar (Duplicate)	6-27-94
O	Goathill Gulch Scar	6-27-94
P	Capulin Mine Dump	6-27-94
Q	Capulin Mine Dump	6-27-94
R	Goathill Mine Dump	6-27-94
S	Sugar Shack West Dump	6-28-94
T	Sugar Shack South Dump	6-28-94
U	Middle Dump	6-28-94
V	Sulphur Gulch Dump	6-28-94
W	Hanson Creek Scar	6-28-94
Soils For	CLP Extraction and TAL Analysis	
CLP (T)-	Eagle Rock Scar	6-27-94
T-2	Goathill Scar	6-27-94
T-3	Capulin Mine Dump @ "P"	6-27-94
T-4	Sulphur Gulch Dump	6-28-94
T-5	Hanson Creek Scar	6-28-94

Attachment D

Sulfate Gain to the Red River over Time in the Vicinity of the Mine.

A release of CERCLA hazardous substances to the Red River has been identified through surface water sampling and sediment sampling. The following exercise was conducted to assess potential attribution of the observed release to the Red River to Molycorp activities.

D-1. Attribution of Release-Method

Attribution of metal loading to the Red River by Molycorp operations was evaluated by examining how the loading of metals to the river has changed over time. Sulfate was used as a proxy for metals since the mobilization of the latter (due to lowered pH) results from the formation of sulfuric acid by the oxidation of sulfate (ref. 62, p. 31). Sulfate loading to the Red River was evaluated near the Molycorp mine by calculating the percent of total sulfate increase or gain attributed to different segments of the river. While another study used this same approach to evaluate gain over a larger reach of the Red River (ref. 28, app. 4), this study concentrated on the gain solely between Molycorp property and the USFS Questa Ranger Station. Sulfate gain was evaluated from the upper Molycorp property line to Columbine Creek (upper segment) and Columbine Creek to Ranger Station (lower segment) for eight different data sets covering 29 years (1965-1994; refs. 28, 13, 14). Sulfate gain for a given data set or sampling event was calculated by multiplying flow of the Red River by sulfate concentration. The total gain was apportioned to each segment. The advantage of this approach is that data from different weather conditions, which would affect the flow of the Red River and sulfate concentrations, can be compared. Due to the differences of sampling strategy of each event, estimations of several parameters such as flow at each river location or sulfate concentration below Columbine Creek was necessary to normalize the data from each study. Any attribution of sulfate loading to the Red River by Molycorp operations would likely be reflected in changes in the relative contribution of sulfate reflected in each segment of the river.

D-2. Attribution of Release-Results and Discussion

If Molycorp's mining operations have contributed to the metal loading of the Red River, then those reaches of the river which are impacted by mining should contribute a higher percentage of the total loading over time. To make this comparison, eight data sets spanning 29 years (1965-1994) were used to determine the contribution from areas between Molycorp milling area and Columbine Creek (upper reach) and between Columbine Creek and the USFS ranger station near Questa (lower reach). For data sets which do not include flows at each sampling location, estimated flows were applied by calculating the proportion of flow at a given location from other data sets (Table D-1). Percentage of flow at each sampling location was fairly consistent regardless of total gauged flow.

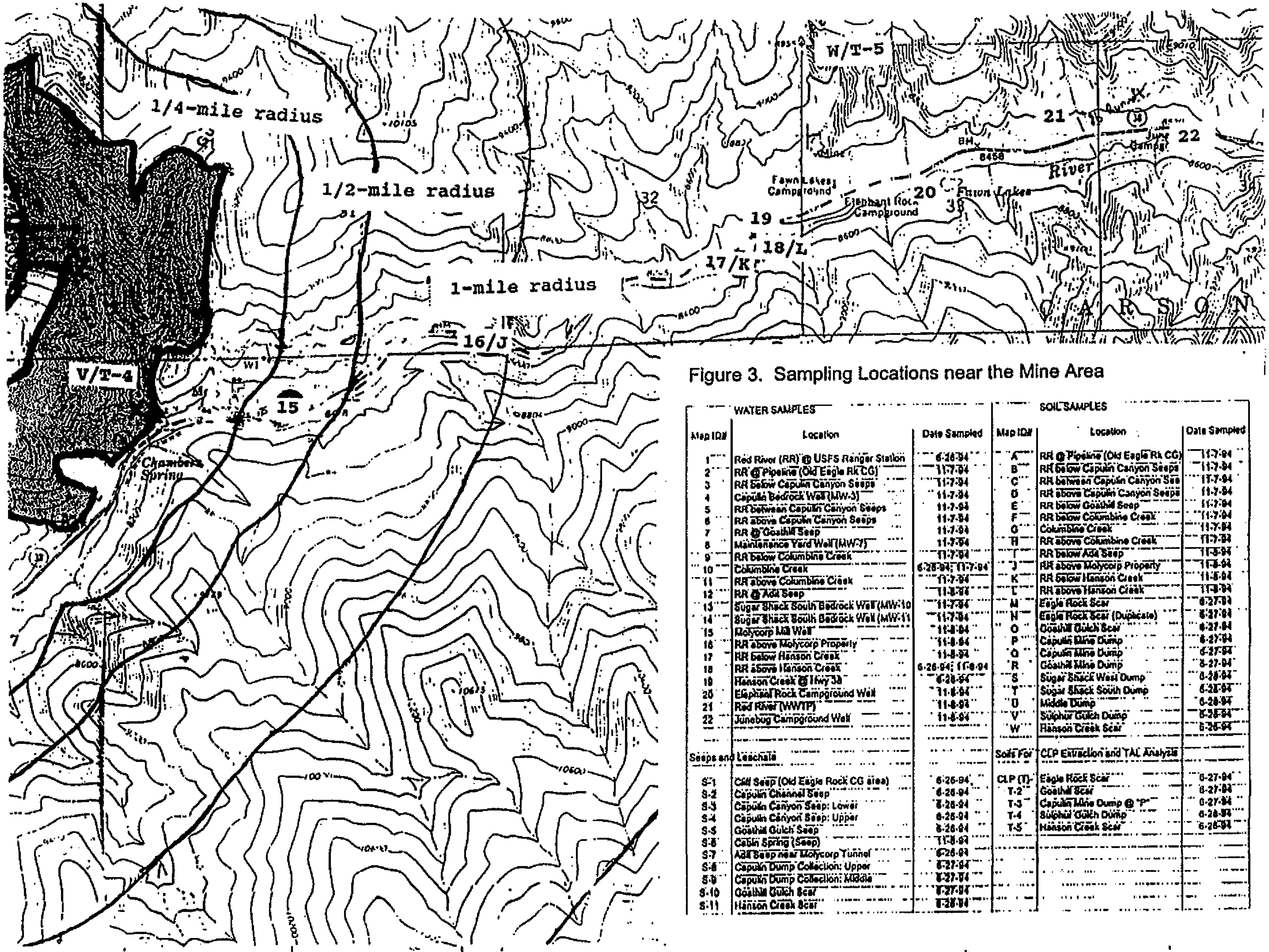
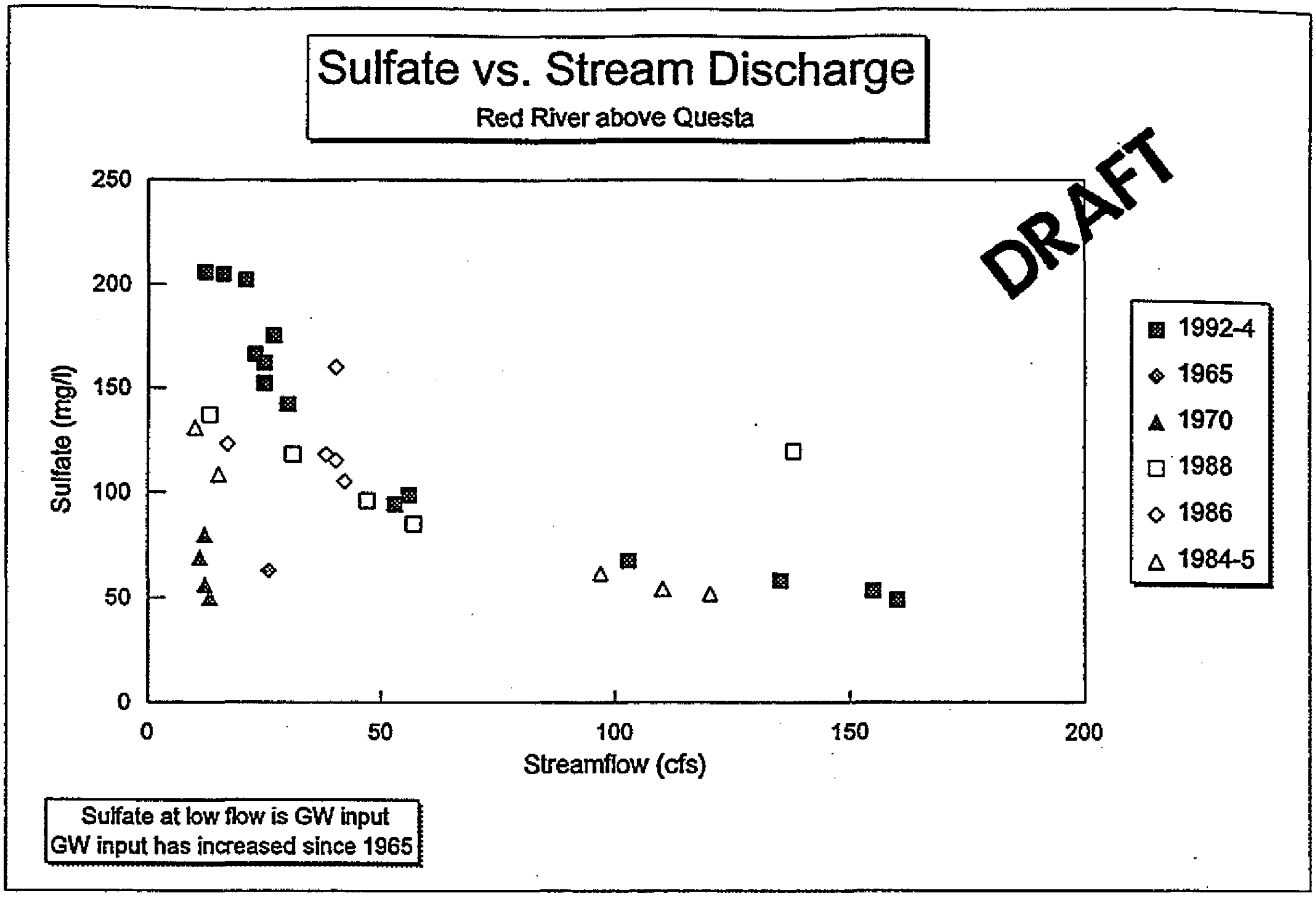


Figure 3. Sampling Locations near the Mine Area

WATER SAMPLES			SOIL SAMPLES		
Map ID#	Location	Date Sampled	Map ID#	Location	Date Sampled
1	Red River (RR) @ USFS Ranger Station	6-26-94	A	RR @ Pipeline (Old Eagle Rk CG)	11-7-94
2	RR @ Pipeline (Old Eagle Rk CG)	11-7-94	B	RR below Capulin Canyon Seeps	11-7-94
3	RR below Capulin Canyon Seeps	11-7-94	C	RR between Capulin Canyon See	11-7-94
4	Capulin Bedrock Well (MW-3)	11-7-94	D	RR above Capulin Canyon Seeps	11-7-94
5	RR between Capulin Canyon Seeps	11-7-94	E	RR below Goathill Seep	11-7-94
6	RR above Capulin Canyon Seeps	11-7-94	F	RR below Columbine Creek	11-7-94
7	RR @ Goathill Seep	11-7-94	G	Columbine Creek	11-7-94
8	Maintenance Yard Well (MW-7)	11-7-94	H	RR above Columbine Creek	11-7-94
9	RR below Columbine Creek	11-7-94	I	RR below Ada Seep	11-8-94
10	Columbine Creek	6-26-94; 11-7-94	J	RR above Molycorp Property	11-8-94
11	RR above Columbine Creek	11-7-94	K	RR below Hanson Creek	11-8-94
12	RR @ Ada Seep	11-8-94	L	RR above Hanson Creek	11-8-94
13	Sugar Shack South Bedrock Well (MW-10	11-7-94	M	Eagle Rock Scar	6-27-94
14	Sugar Shack South Bedrock Well (MW-11	11-7-94	N	Eagle Rock Scar (Duplicate)	6-27-94
15	Molycorp Mill Well	11-8-94	O	Goathill Gulch Scar	6-27-94
16	RR above Molycorp Property	11-8-94	P	Capulin Mine Dump	6-27-94
17	RR below Hanson Creek	11-8-94	Q	Capulin Mine Dump	6-27-94
18	RR above Hanson Creek	6-26-94; 11-8-94	R	Goathill Mine Dump	6-27-94
19	Hanson Creek @ Hwy 38	6-28-94	S	Sugar Shack West Dump	6-28-94
20	Elephant Rock Campground Well	11-8-94	T	Sugar Shack South Dump	6-28-94
21	Red River (WWTP)	11-8-94	U	Middle Dump	6-28-94
22	Junebug Campground Well	11-8-94	V	Sulphur Gulch Dump	6-28-94
			W	Hanson Creek Scar	6-28-94
Seeps and Leachate			Soils For	CLP Extraction and TAL Analysis	
S-1	Cliff Seep (Old Eagle Rock CG area)	6-26-94	CLP (T)-	Eagle Rock Scar	6-27-94
S-2	Capulin Channel Seep	6-26-94	T-2	Goathill Scar	6-27-94
S-3	Capulin Canyon Seep: Lower	6-26-94	T-3	Capulin Mine Dump @ "P"	6-27-94
S-4	Capulin Canyon Seep: Upper	6-26-94	T-4	Sulphur Gulch Dump	6-28-94
S-5	Goathill Gulch Seep	6-26-94	T-5	Hanson Creek Scar	6-28-94
S-6	Cabin Spring (Seep)	11-8-94			
S-7	Ada Seep near Molycorp Tunnel	6-26-94			
S-8	Capulin Dump Collection: Upper	6-27-94			
S-9	Capulin Dump Collection: Middle	6-27-94			
S-10	Goathill Gulch Scar	6-27-94			
S-11	Hanson Creek Scar	6-28-94			

Results of the contribution of sulfate from each stream reach over time is presented in Table D-2. Prior to the commencement of open pit mining by Molycorp, the lower reach contributed slightly over a half of the total gain. The mine dumps were initially deposited in the Sulphur Gulch drainage and small drainages in the Sugar Shack South area (ref. 4, photo 6). Analytical results from a 1971 report show the upper reach had a higher percent contribution of sulfate than before open pit mining began (Table D-2; ref. 14, p. 41). By 1988 (next available data set), deposition of the mine waste dumps had expanded into both Goathill Gulch and Capulin Canyon (ref. 4, photo. 7). Also, Molycorp had suspended open pit operations in 1985 and reverted to underground techniques. The contribution of sulfate observed in the lower reach of the river had increased to over 80% of the total gain (Table D-2). Analytical results of surface water flow from each of these drainage demonstrated higher levels of sulfate than in background drainages such as Hanson Creek (ref. 28, app. 1). The Capulin collection system, which was installed in 1992, re-routed acid drainage (both mine and scar related) to groundwater via a bore hole in Goathill Gulch. This action cut off much of the surface water flow in these drainages. The contribution of sulfate gain seen in the lower reach of the Red River abruptly decreased by October of 1992 to 52% (Table D-2). This level of contribution is approximately the same as that prior to open pit operations. Since the installation of the collection system, however, the sulfate gain in the lower stream reach has increased (Table D-2). This result suggests that a new source for sulfate had developed since 1992. Because the hydrothermal scar areas have not likely increased in surface area since 1992 and can be assumed to already have achieved its greatest acid generating potential, the increase in sulfate most likely has resulted from groundwater recharge which is impacted by either the mine waste dumps or mine workings.

An alternative method for evaluating (partial) attribution of releases to the Red River focused upon metal concentrations in both the sediments which defined a release and the mine waste dumps. Those metals which were higher in concentration in the mine waste dumps than the scar areas were compared to those metals which demonstrated a three-fold increase in the sediment samples. A ratio of average metal concentrations in mine dump material to natural scar material was calculated (Table 4). The highest ratios are those for Mo, Zn, Cu, Mn and Be (in decreasing order). Except for Mo, for which sediment analysis was not conducted, four of the five metals which were elevated in at least half of the downstream sediment samples are the same metals with the highest concentration ratio between the mine dump material and scar areas (ca. Table 4 and Table 18). With the few number of samples (waste and sediment), this comparison does not definitively prove attribution of elevated metal concentrations to Molycorp but does suggest a likely connection.



Sulfate at low flow is GW input
GW input has increased since 1965

APPENDIX B

Discussion of Molycorp mine area hydrogeology, excerpted from SPRI Report, April 21, 1995.

APPENDIX B

Discussion Of Mine Area Hydrogeology

B.1 HYDROGEOLOGIC UNITS

In the Mine Area, the identified hydrogeologic units are:

- Pre-Cambrian/Tertiary Aquitard,
- Tertiary Aquifer,
- Hydrothermal Alteration ("Scar") Aquitard [Note: not a true aquitard because it is not in the saturated zone]
- Valley-Fill/Mudflow Aquifer,
- Valley-Fill/River Alluvium Aquifer, and
- Mine Waste-Rock Dumps (Perched Aquifer).

Each of these units is discussed below.

Pre-Cambrian/Tertiary Aquitard

The Pre-Cambrian metamorphic and intrusive rocks and the stock-like Tertiary intrusives (Mine Aplite) form a hydrogeological basement or a regional aquitard analogous to the regional lower clastic (Pre-Cambrian/Cambrian quartzites) aquitard identified by Winograd and Thordarson (1975) in central and eastern Nevada. While shallow fracture systems (and in some cases, major through-going faults) allow for some movement of ground water, these rocks are characterized by low hydraulic conductivity and serve as barriers to deep circulation of ground water. Schilling (1956), in characterizing the vertical fracture system in the Mine Aplite, noted that these fractures pinch out downward into the main intrusive mass. These fractures (along with numerous small faults) are also mineralized in the ring fracture fault zone.

Tertiary Aquifer

The Tertiary volcanics and sedimentary rock units are highly fractured and faulted throughout the caldera block north of the river. (Note: sedimentary units are very thin and do not show on Figure A1 - Appendix A.) The major structural features are high-angle northwest-, north-, and northeast-trending faults and low-angle faults, either parallel to the intrusive/volcanic contact (contact conformable fractures) or along unit contacts. Joints related to some combination of tectonic and volcanic processes are also present in the volcanic units.

Although mineralization and/or clay gouge along faults have sealed some of the fractures, not all are sealed and fracture flow does occur throughout the area. The Tertiary volcanic rock then represents the aquifer in the area and has highly variable hydraulic conductivity depending on the fracture orientation, fracture spacing, and the openness of the fracture system below the water table.

Hydrothermal Alteration ("Scar") Aquitard

The hydrothermal scars scattered across the ridges above the mined area are composed of pyrite, clay, quartz, and carbonates altered to iron oxide, gypsum, jarosite, plus residual quartz and clay resulting from near-surface oxidation processes. These masses of altered material are principally located above the natural water table, but they likely have very low hydraulic conductivity and serve to retard infiltration to the fractured Tertiary aquifer system. Several 90-foot deep boreholes drilled by Molycorp into the "scar" material were either dry or produced very small flows (on the order of less than 1 gallon per minute) over time. Because masses of fractured rock are located within the hydrothermal "scars," some of this flow may have been from local perched water zones associated with isolated masses of rock. If the "scar" material extends below the water table, the altered rock might locally create semi-confined conditions.

Valley-Fill/Mudflow Aquifer

Schilling (1956) described and mapped mudflow deposits in the Sulphur Gulch area and related these flows to intense storms that periodically flushed valley debris to the Red River Valley. He noted that the mudflows tended to develop in tributary canyons that extend across the hydrothermal scar areas transporting the hydrothermally altered rock toward the main valley. At times, flows blocked the Red River Valley and spread laterally—covering parts of the valley floor. SPRI field observations were that mudflow deposits extend beyond the area mapped by Schilling and are present at Goathill Gulch and Capulin Canyon. These mudflow accumulations, interbedded with alluvial sands and gravels, make up the fan delta deposits that occur at the lower part of many of the tributary canyons. Because hydrothermally altered rock underlies so much of the land north of the river (Appendix A), virtually all of the tributary canyons have some mudflow debris composed of acid-generating rock within the fan delta deposits. The large fan delta complexes at Hanson and Hot-N-Tot Creeks, Sulphur Gulch, Goathill Gulch, and Capulin Canyon are examples of deposits that contain acid-generating mudflow debris.

The mudflow material consists of angular, poorly sorted rock ranging from pebble to boulder sizes in a matrix containing varying amounts of clay, slit, and sand. Field observations of these deposits and borehole logs show that thin layers of sandy, silty clay are present within the mudflow. Drilling has also encountered buried logs in these deposits.

Mudflow sediments from the tributary canyons should interfinger with the river alluvium, but drillers' lithologic logs for the Columbine and Mill wells on or close to the Red River Valley floor are not of sufficient detail to recognize this. Ephemeral flows and seepage from tributary canyons should infiltrate the mudflow sediment and these deposits can serve as a conduit between the tributary canyons and the main valley. Exposure of these mudflow deposits are gypsiferous resulting from precipitation of gypsum from pore waters and/or reactions between acidic pore water and pyritic debris. In either case, the fan delta deposits themselves may become sources of high TDS and sulfate-bearing acidic water. In the main valley, mudflow deposits may be part of the saturated valley-fill.

Valley-Fill/River Alluvium Aquifer

Drillers' logs characterize the river alluvium as rounded gravels (ranging from pebbles to boulder size) and fine to coarse sand. Pumpage at Columbine wells No. 1 and No. 2 was in the 1,000 gpm range (Molycorp files). In the mill area, which was built on a broad flat surface north of the Red River, Mill well No. 1 pumped at 1,200 gpm. Mill well No. 1A initially pumped up to 1,500 gpm, but the well could not sustain this level and was pumped dry shortly after completion. Other wells attempted in the mill area were not productive. Well logs to-date indicate that bedrock lies at depths of 80 to 150 feet below the valley floor.

Mine Waste-Rock Dumps (Perched Aquifer)

The mine waste-rock dumps are fairly permeable relative to the underlying bedrock. The dumps are recharged from snow melt and other precipitation events. That they store water for some period of time is evidenced by the acidic, high TDS and high sulfate waters discharged in some places from the lower part of these rock piles. Recharged water has sufficient residence time to react with available sulfide (chiefly pyrite) to generate acidic conditions. Mine waste-rock dumps function as perched aquifers that discharge water to surface seeps and flows, to valley-fill sediments, and to fractured bedrock.

Mine waste-rock dumps occur at the head of Capulin Canyon and Goathill Gulch. Farther south, the Sugar Shack West dump was built across a small canyon that merges near Shaft No. 2 with a larger canyon tributary to the Red River. Sugar Shack South Dump, the Middle Dump, and the Sulphur Gulch/Spring Gulch Dump were built across drainages tributary to the Red River. These dumps were constructed from rock excavated when the open pit was developed. Berms (to control rock falls and slides from the waste-rock dumps) were constructed from local valley-fill material and extended across the tributary valleys prior to the building of the waste-rock piles. Geologic maps, cross-sections of the pit area, and borehole logs with or without geochemistry indicate that the dominant rock types were andesitic flow rocks and aplite with subordinate amounts of granite porphyry and rhyolitic ash flow tuffs. Virtually all of these rock types (including overburden rock, subeconomic waste rock, and ore) normally carry some disseminated pyrite. Most of the ore mineralization was in the aplite and the andesite. Mine waste-rock ranges from fresh, weakly altered rock to rock consisting largely of quartz, clay, and pyrite (or its oxidized equivalent). Occasionally, rock fragments at the toe of the dump will disintegrate very easily because of the growth of intergranular gypsum precipitated from dump waters. Qualitative observation of waste-rock piles indicates that dump material ranges from clay to boulder sizes. The dump material shows "angle of repose" layering resulting from variations in time of the size fragments excavated. Downward flow of water in this unsaturated environment should be enhanced by the angle of repose layering.

B.2 GROUND-WATER RECHARGE

Factors to be evaluated in preparing estimates of ground-water recharge include: topography (elevation, degree of slope); surface material (outcrop, soil sediment); permeability and run-off characteristics of surface material; bedrock conditions in terms of infiltration characteristics, porosity, and hydraulic conductivity; and climate (temperature, precipitation, evaporation). Many of these parameters are not well defined in the Red River drainage area, but there are sufficient data to make some estimates of a hydraulic connection between ground water and the Red River.

The mine operations are located north of the Red River Valley where elevations range from 7,581 feet on the Red River opposite Capulin Canyon to 10,812 feet at the ridge north of the open pit, resulting in a relief of 3,221 feet. Excluding the relatively narrow flat to gently rolling valley floor, most of the topography is composed of steep to very steep slopes that are conducive to high rates of runoff. Major tributary canyons in the Mine Area have gradients on the order of 600 to 800 feet per mile.

The U.S. Soil Conservation Service (1982) defined four soil map units (as part of their soil survey of Taos County) in the Mine Area north of the Red River:

- Two of the soil units (Rock Outcrop/Ustorthentis Complex and Marosa Soil/Rock Outcrop Complex) are described as gravelly and/or sandy loams. These soils are characterized by rapid to moderate run-off with high erosion potential. Infiltration (number of inches per hour that water percolates downward in the soil) ranges from 0.6 to 6 inches. The soil units are described as complex because a significant percentage of the map area consists of outcrops of igneous and metamorphic rocks. Vegetative cover consists of Douglas fir, Engelmann spruce, and Ponderosa pine with an understory of Gambel oak, mountain brome, kinnikinnick, Kentucky bluegrass, Arizona fescue, and whortleberry.

- The third soil unit (Rock Outcrop/Badland Type) is associated with the hydrothermal scars and underlies much of the area north of the Red River

(Appendix A). This soil is described as extremely acidic (pH <4.5). It occurs along portions of all of the major drainages (Capulin, Goathill, Spring & Sulphur Gulch). Typically, slopes are steep and are nearly barren of vegetation. The Soil Conservation Service characterizes this unit as a soil that generates increasing sediment loads to tributary drainage as precipitation increases (very high run-off and erosion potential). Drainages that intersect the hydrothermal scar areas typically have mudflow deposits near their confluence with the Red River.

- The fourth soil unit (Cumulii Hoplobenolls) covers parts of the main valley floor. It generally consists of stratified gravelly sandy loams and gravelly clays. Infiltration of the soil is slow to moderate (0.2 to 2 inches per hour). Periodic flooding is the chief hazard here.

Rainfall estimates related to elevation and soil units in the Mine Area were prepared by the U.S. Soil Conservation Service (1982). For the lower elevation, below 9,000 feet, the annual precipitation is 18 inches; between 9,000 to 11,000 feet, annual precipitation is 35 inches. In its report, the U.S. Soil Conservation Service indicates that annual snowfall can exceed 100 inches in the mountains. Schilling (1956) had estimated 21 inches of annual precipitation for the same area. The bulk of the precipitation is winter snowfall with some thunderstorm contribution during the summer months. The average annual temperature is 40° to 42° Fahrenheit.

Several authors have attempted to estimate the distribution of precipitation among run-off, evapotranspiration, and ground-water recharge. Wilson and Associates (1978) estimated that in the mountainous areas of northern New Mexico, 3 to 10 inches of the precipitation contributed to run-off and the balance was distributed between evapotranspiration and recharge to ground water. Vail Engineering (1989) measured the areas of drainage basins for the major tributary to the Rio Grande, including the Red River, and calculated basin discharges from an equation based on drainage basin area and average annual winter precipitation. For the lower Red River basin (Zwergle Dam east of the Town of Red River to the Questa Ranger Station stream gauge), Vail calculated a discharge of 38.2 cubic feet per second (cfs). A review of flow discharges measured over a 12-year period [U.S. Geological Survey (USGS) data in Molycorp files for 1943 to 1955] shows that discharge ranges from 7.74 cfs to 262.5 cfs. In general, the higher flow rates occur in the April through July period and the lower rates over the balance of the year. Overall, this section of the Red River between the dam and the Ranger Station appears to be a gaining stream with substantially higher flow discharge at the downstream station.

River accretion studies by the USGS (in October 1965 and in 1988) were referenced by Smolka and Tague (1988) in their water quality survey of the Red River between Zwergle Dam and the Fish Hatchery. After correcting for tributary and diversion flows, they estimate that the net gains from ground water were 9.0 cfs (1965) and 9.1 cfs (1988) between Zwergle Dam and the Ranger Station gauge east of Questa. The Molycorp mill was not in operation in 1965 or 1988 and was not a factor in the diversion calculations. A review of the 1943-1955 flow data (Molycorp files) for these two gauges indicate that base flow (ground-water recharge) conditions ranged from 7.74 cfs to 13.9 cfs (an average of 11.04 cfs). This data set also shows that base flow conditions are typically in December and January, and Smolka and Tague's estimate for net gain to ground water may be too high. Vail (1989) used USGS stream flow data to estimate accretion to the Red River at nine locations from the Zwergle Dam site to the Bear Canyon area (near the Questa Ranger Station gauge). The segment from the Molycorp mill downstream to Bear Canyon is estimated to have an accretion of 6.6 cfs. Of this, 5.0 cfs comes from Columbine Creek, which leaves 1.6 cfs related to recharge from intermittent tributary drainages, seeps, and springs along both sides of the rivers.

Another approach to estimating drainage basin recharge to ground water utilizes the Maxey and Eakien (1949) approach. Their method estimates that 25 percent of the annual precipitation over the Mine Area drainage basin could contribute to recharge. Vail Engineering (1989) calculated areas for the Red River drainage basin and for the lower Red River basin (from Zwergle Dam to the Ranger Station). Using an area of 83.24 square miles at 25 percent of 21 inches annual precipitation (Schilling, 1956), the entire basin would contribute 32.25 cfs to ground water. That part of the entire drainage basin in the Mine Area represents about 6 percent of the total drainage basin. On the assumption of a uniform distribution of ground-water recharge (as an approximation), 1.94 cfs would be recharged to the ground water. Using Vail's (1989) estimate of the square miles for discrete elevation zones and 25 percent of the annual precipitation for each zone as recharge results in a higher estimate of 2.56 cfs ground-water recharge for the Mine Area drainage basin. SPRI (1993b), using a similar approach for the Mine Area drainage basin (Capulin Canyon to Spring & Sulphur Gulch), calculated a ground-water recharge of 1.45 cfs. If a water balance is assumed, this recharge equals accretion to the Red River.

A final approach to estimating recharge from ground water is to use the average of the baseflow from the 1943 to 1955 flow data (11.04 cfs) as an estimate of the total ground-water recharge for the basin. Again, with the assumption of an uniform distribution of recharge throughout the basin, the Mine Area portion of the drainage basin (6 percent of total area) would have contributed 0.66 cfs. This value is considerably lower than the precipitation-based estimates. The lower recharge values will be used here because there may be less error for a recharge estimate based on actual flow data than for estimates based on a precipitation approximation.

Vail Engineering's (1989) accretion study results in an estimate of 1.6 cfs of ground-water recharge in the river from both sides of the segment opposite the mine. This would result in about 0.8 cfs from the north (mine side) of the river, which is in fairly good agreement with the base flow estimate.

Molycorp records indicate when the deep underground mine was being developed, dewatering required between 250 and 500 gpm (0.57 to 1.14 cfs). The Smolka and Tague (1988) accretion study, during the time of mine development, shows a net accretion to the river from ground water of 9.0 cfs, similar to the pre-mine accretion of 9.1 cfs in 1965. Taken at face value, this suggests that the mine was dewatered from the deeper part of the ground-water flow system and did not appreciably, if at all, reduce accretion to the river from ground water. The explanation for this is that most of the ground-water recharge to the river may have come from the upper part of the ground-water system. In other words, the deep mine was not directly in the recharge zone. Schilling (1956), in his description of fracturing in the Sulphur Gulch area, indicated that many of the fractures (particularly sheeting type of fracturing related to contacts) tend to die out with depth. More water was probably in storage in the shallow, more open, and better interconnected fracture system close to the water table, and mineralization combined with lithostatic pressure effectively sealed much of the deeper level fractures. With lower hydraulic conductivity conditions at depth, a cone of depression (probably steep-sided) would develop over the deep mine. SPRI (1993b, 1994) concluded that the cone probably did not extend to the river.

The stability of the water levels in the monitor wells over the last five months, despite continuous dewatering of the underground mine (several hundred feet decline over the same period), supports the interpretation that a steep cone of depression occurs over the mine, and that the edge of the cone is north of the river. The wells close to the river could possibly be recharged at a rate which balances any loss (discharge) due to dewatering. Water-quality data from 1994 sampling of the river and of the monitor wells, in terms of dilution affect, is inconclusive because there is no historical water-quality data. Concentrations of sulfate in well water ranges from 700 to 1,300 mg/L while river water is typically less than 20 mg/L. As water-quality samples are taken over the next year, it may be possible to evaluate dilution affects, if any.

B.3 PRE-MINE WATER-TABLE CONFIGURATION

Based on Molycorp data (obtained in 1993), dewatering inflow for the older underground workings and for the open pit ranged from 15 to 30 gpm, which are very low flow rates. However, anecdotal evidence from mine workers active at the open pit indicate that an extensive water control program was in operation during the development of the pit and that these rates may be low. If these areas were below the water table, such rates could only be explained by very tight rock conditions in which virtually all the fractures were sealed.

being located close to a north-south fracture zone. An estimate for transmissivity based on the specific capacity:

$$\left(\frac{Q}{s}\right)=\left(\frac{60gpm}{1foot}\right)$$

and utilizing an equation developed by Huntley et al. (1992) for fractured rock

$$T=K\left(\frac{Q}{s}\right)^{1.18}$$ where K is a conversion factor from their Table 1

resulted in a transmissivity of 4,877 ft^2/d, or 36,481 gpd/ft. (Note: The factor to convert from ft^2/d to gpd/ft is 7.48.)

The thickness of the bedrock aquifer is unknown. Using the saturated thickness at the well (58 feet), an estimated hydraulic conductivity (K) is 629 gpd/ft^2. This is probably close to a maximum value (thickness is too small), but still lies within the upper range of K values for fractured igneous rock (Freeze and Cherry, 1979, Table 2.2).

Another approach to estimating hydraulic conductivity uses the decline in water level at the underground mine during the current dewatering phase and dates of measurement on a time-drawdown plot. Data were plotted on semi-log pager and the Cooper-Jacobs equation was used to calculate transmissivity.

$$T=\left(\frac{264Q}{\Delta s}\right)$$

This calculation resulted in a transmissivity of 2,424 gpd/ft and a hydraulic conductivity of 5.09 gpd/ft^2 (the latter is based on a thickness of 476 feet or the difference between the pre-dewatering water-level and the top of the Grizzly level at the underground mine). The Cooper-Jacobs equation was developed for porous media. Its application to bedrock data assumes that over a large enough volume of rock ("large enough" is not specified), fractured rock can be approximated by a porous media formula.

The two values for hydraulic conductivity reported here are at best rough estimates. These results suggest that hydraulic conductivity ranges over two orders of magnitude from fairly tight rock to permeable fracture zones. A compilation of flow velocity based on simple analytical equations using single hydraulic conductivity values does not lead to reliable estimates for travel time. Even if the estimate was close to a true travel time, open fault zones at an angle to the regional gradient can move ground water more rapidly and in a different direction from the regional flow direction. Estimates of flow velocity and travel time, based on water quality (from known sources) and isotopic data, may have more validity (when the data from such studies become available) than hydrogeological approximations.

B.5 GROUND-WATER TRANSPORT

With the currently available information, it is not possible to make meaningful quantitative estimates for the velocity of ground water through the fractured bedrock. Tracer tests in sets of nearby boreholes would probably allow for an estimate of ground-water velocity through fractures. For these tests, the distances between boreholes and their relationship to mapped fractured systems would have to be considered. However, as indicated in previous sections, water chemistry combined with isotope data might lead to better estimates for velocity.

Seepage velocity formulas are based on advection in granular material, not fractured rock. Moreover, conceptual models for fracture flow include an equivalent porous media model that treats fractured rock as if it were a granular, porous medium. The rationale is that if the fracture spacing is small (compared to the scale of the system being studied), the model leads to a reasonable estimate of regional flow. The model is not an accurate representation of local conditions (e.g., an open fault that diverts flow at some angle to the regional system).

Using the caved area (located on Goathill Gulch) above the deep underground workings as a source and published values for hydraulic conductivity and porosity for fractured rock (Freeze and Cherry, 1979), rough estimates of travel time from the mine to the river can be made. According to Freeze and Cherry (1979), the range of hydraulic conductivity for fractured igneous and metamorphic rocks is 10^{-1} to 10^{3} gallons/day/ft^2 and for permeable basalt 1 to 10^5 gallons/day/ft^2. The porosity range for fractured crystalline rock is 0 to 10 percent, and for fractured basalt 5 to 50 percent.

The seepage velocity formula is:

$$V = \frac{Ki}{7.48 n_e}$$

where: V = seepage velocity, in feet/day;
K = hydraulic conductivity, in gallons/day/square foot;
i = hydraulic gradient, in feet/feet;
n_e = porosity, as a percent; and
7.48 = gallons per cubic foot.

The hydraulic gradient (0.036 ft/ft) and the down-gradient distance to the river from the caved area (3,500 feet) are based on a "normal" water-table configuration map. Seepage velocity was estimated by using a hydraulic conductivity equal to 10 gallons/day/ft^2 and a porosity of 10 percent. These values are in the mid- to upper-range of values for fractured igneous and metamorphic rocks and in the lower range for permeable basalt. The resulting seepage velocity is 0.48 foot/day and the travel time from the caved area to the river is 19.97 years. High-angle faults that cut across the structure of the mineralized zone and the low-angle north- and west-dipping faults may represent preferential pathways for flow to the river at rates less than the calculation indicates. However, estimates of seepage velocity and travel time calculated from formulas *derived from granular or matrix flow* and applied to a setting where hydraulic conductivity is highly variable are not accurate.

APPENDIX C

Report on the installation and testing of 12 new monitoring wells at Molycorp mine in 1994, excerpted from SPRI Report, April 21, 1995.

3.0 RESULTS AND DISCUSSION OF SPRI SUMMER/FALL 1994 FIELD ACTIVITIES

3.1 WELL EMPLACEMENTS

To identify and evaluate the presence of potential hydrogeologic connections between the waste-rock dumps, down-gradient aquifers, and the Red River, aerial photographs were used to locate the monitor/extraction wells as close as possible to the pre-1963 valley bottom. [In a number of areas, waste-rock dumps and/or mine cut-and-fill operations have subsequently covered these drainages. The fan delta deposits (alluvial sediments and mudflow deposits, collectively called the *valley-fill aquifer*) occur at the mouths of tributary valleys to the Red River (see Figure 4).]

The equipment used to drill the monitor/extraction wells consisted of a casing drive system using 8-inch and 12-inch inside diameter (ID) threaded drive casing. A casing drive shoe was attached to the base of the casing driver and remained at the bottom of the cased hole after hydraulic jacks extracted the drive casing. Well construction and placement of annular materials were accomplished inside the drive casing, limiting the well casing to 8 inches or less inside the 12-inch drive casing and 6 inches or less inside the 8-inch drive casing. A downhole air hammer and hammer bit were used to drill through boulders and bedrock. The drill equipment consisted of a 15W Gardner Denver Tophead drive chain pulldown drill rig, water truck, pipe truck, air compressor truck (primary), tag-along air compressor (secondary), and hydraulic jacks' truck.

All wells that had water in the borehole were developed by either pneumatic downhole bladder pump, bailing, or electric submersible pump. Low-yield wells were pumped using the pneumatic bladder pumps (for their design protections against pump burnup). The medium-yield wells were pumped by continuous bailing with an 18-gallon bailer. The bailing operation used a hydraulic powered 5T Smeal pump truck to raise and lower the bailer. Bailing rates were adjusted to fit each well's yield so as to allow for baildown without undue interruption of the extraction rate. High-yield wells were pumped with either one horsepower (hp) or 5 hp electric submersible well pumps. The actual high-end pumping rate varied with head considerations, but the 5 hp pump would usually pump up to 50 gallons per minute.

When the locations of the monitor wells were established and surveyed for elevation by Molycorp staff, elevations for wells with protruding casing vaults were taken at the top of the casing and elevations for wells with flush-mounted vaults were taken at the top of the cement pad. All measuring point elevations have been corrected to read from the top of the cement pad.

3.2 WATER LEVELS AND HYDRAULIC CONNECTIONS

SPRI overviewed the installation of 12 new monitor wells during the 1994 investigation (refer to Figures 2 and 10 for locations). These wells and their hydrologic characteristics are described below.

Wells MMW-14 and MMW-16

These wells, which are located in the fan delta or valley-fill deposits and the immediately underlying bedrock opposite the Sulphur Gulch and Spring Gulch area, are dry. The open pit (Sulphur Gulch) and the decline that passes under lower Sulphur Gulch may capture most of the discharge from the drainage basin. (These wells are not deep enough to intersect the cone of depression if it extends into this area.)

Well MMW-13

This well was drilled opposite the Middle Dump and extended initially into bedrock (25 feet); it was completed as a valley-fill well since the bedrock was dry. It is difficult to distinguish reworked valley-fill from in-situ valley-fill by drill cuttings alone. Berms were constructed across the lower parts of some tributary valleys prior to dump construction. Using elevations for the pre-berm surface from the 1963 USGS topographic map (Questa, NM 7.5 Minute Quadrangle Map) and more recent mine topographic maps, the upper 50 to 70 feet of sandy gravel at MMW-13 appear to be berm material. The lower 15 feet of the valley-fill was saturated. The water-level elevation at this well is low (7,963 feet) when compared to the stream bed elevation opposite the well (7,990 to 8,000 feet). This water-level elevation has changed less than 1.0 foot over the five-month period since construction. The water level will continue to be monitored for evidence of additional drawdown related to the mine cone of depression.

Wells MMW-10A, B, C

These wells are located below the toe of Sugar Shack South Dump. The elevation of the Red River opposite these wells is between 7,910 and 7,920 feet. The water quality of Portal Springs (a series of river bank seeps along the north side of the river) is commensurate with natural acidic sources and/or waste-rock dumps. The eastern most seep (located just west of the MMW-10 wells) has an estimated elevation of 7,915 feet. As discussed later in this section, these seeps are believed to represent the top of the potentiometric surface at the river. Water-level elevations at the three MMW-10 wells are slightly above 7,917 feet.

Same as
[illegible] 3

Monitor well MMW-10A is screened in the lower part of the valley-fill, immediately above bedrock. The borehole log indicates that the fill here is a mixture of fluvial sands and gravel and mudflow deposits. Clay beds interbedded in the valley-fill probably resulted from deposition in lakes formed behind contemporaneous mudflows that blocked the Red River Valley. The aquifer test results discussed in Section 3.3 indicate that this well, if fully stressed, may produce several hundred gallons per minute from the saturated sands and gravels.

MMW-10B is screened in bedrock just below the valley-fill, but the water-level elevation (7,917 feet) is 112 feet above the contact, indicative of a strong upward gradient. This water-level elevation is close to that of the two valley-fill wells which, since the bedrock is highly fractured below the fill, could also be interpreted to mean that the fill and the shallow bedrock are in hydraulic continuity. As discussed in Section 3.3, the aquifer test at MMW-10A established some hydraulic connection between the valley-fill aquifer and the underlying bedrock aquifer (MMW-10B) because both wells gave drawdown effects during the test. The head relationship between the valley-fill and the bedrock aquifers may have a seasonal component with higher heads in the bedrock during spring recharge.

MMW-10C is screened in the upper part of the valley-fill, just above a thick clay bed. It is conceivable that MMW-10C intercepts a perched zone, and the configuration of the perched water table is not dependent on the main water table. A more likely explanation is that the clay beds (just below the total depth for MMW-10C) retarded vertical flow and, because of the short duration of the aquifer test (100 minutes), there was very little drawdown at MMW-10C. An interpretation is that MMW-10C and MMW-10A are part of a continuous zone of saturation and that the clay bed is the cause of the lack of response during the aquifer test.

Well MMW-11

MMW-11 was completed in the upper part of the bedrock aquifer, just south of the toe of Sugar Shack South Dump. During the drilling of this well, the lower part of the dump material was described as moist, but free water (described as dark turbid water) did not appear until 93 feet. This description corresponds with the base of the dump material. Immediately underlying the dump material is a thin sandy gravel followed by 10 feet of gravelly clay. Small amounts of water [a few gallons per minute (gpm)] were reportedly produced throughout the valley-fill, but because a mixture of foam and water was being injected during drilling, the extent of saturation in the valley-fill is unknown. It is possible that the water at 93 feet infiltrated from the overlying dump material and represents a thin perched zone. The water-level elevation for the bedrock aquifer at MMW-11 is 7,915 feet, or 58 feet above the valley-fill and bedrock contact. This indicates a strong upward gradient which would be expected near the zone of discharge in the Red River valley. The water-level elevation for the valley-fill aquifer at MMW-11 is not known.

During the development (using air lift) of MMW-11, the bedrock aquifer had a pumping rate (Q) of 60 gpm with less than one (1) foot of drawdown (s). According to Huntley et al. (1992), the use of specific capacity formulas based on alluvial aquifer studies can be used to estimate transmissivity (T) for fractured rock. Using the equation:

$$T = K\left(\frac{Q}{s}\right)^{1.18}$$

where Q = 60 gpm
s = 1 foot, and
K = 38.9 [a conversion factor from Table 1 (Huntley et al., 1992); NOTE: This K is not equal to permeability]

a transmissivity (T) of 4,877 ft^2/day (36,479 gpd/ft) was calculated. (NOTE: The factor to convert from ft^2/day to gpd/ft is 7.48 gallons/foot.) This value contrasts with 90,000 gpd/ft based on the standard alluvial equation estimate:

$$T = \left(\frac{Q}{s}\right)1500$$

It is difficult to estimate hydraulic conductivity since the actual thickness of the aquifer is not known. If the thickness of bedrock aquifer open to the screen (40 feet) is used, a maximum value for K would be 912 gpd/ft^2. This value is close to the upper limit for fractured igneous rock (Freeze and Cherry, 1979) and could be a significant overestimation.

MMW-11 may be located near the outer edge of the cone of depression. Over the last five months, corresponding with dewatering of the underground mine, the water level at this well has shown fluctuations of less than 0.5 foot.

Figure 5 is a cross-section illustrating hydrogeologic relationships in the area of Sugar Shack South.

Wells MMW-8A and -8B

Monitor well MMW-8A (screened in bedrock) and MMW-8B (screened in valley-fill) are located on a fan delta deposit that filled an unnamed tributary valley in the area of Shaft No. 1. These wells are close to the river (within 250 feet). Water-level elevations for both wells are within the contour interval (10 feet) along the Red River opposite the well. It is not clear that the MMW-8 wells are within the cone of depression. Recharge from ground water beneath the river may balance discharge to the dewatering center, keeping water levels at about the same elevation. Additional monthly water-level measurements may help resolve the issue. The bedrock well (MMW-8A) has a slightly higher water level than the valley-fill well (MMW-8B), indicating a weak upward gradient.

Well MMW-7

This well (north of Shaft No. 1) was drilled to a depth of 161 feet and screened in bedrock. The water level here is 8,029 feet, which is approximately 550 feet or more above the current cone of depression. This well is screened in andesitic flow rock characterized by a series of low-angle north-dipping faults (Figure 3). Drill cuttings and drilling conditions indicated that the andesite is highly fractured. The potentiometric water level here is above the valley-fill/bedrock contacts. Valley-fill appeared to be unsaturated at MMW-7, and no perched zone within the fill was noted. MMW-7 appeared to have intercepted a perched zone within bedrock. This perched zone is confined to an interval of fractured rocks apparently associated with a series of low-angle structures. Figure 6 is a cross-section illustrating hydrogeological relationships at the MMW-7 and MMW-8 wells.

Upper Goathill Gulch drainage flows into the caved area. With the level of dewatering maintained below the elevation of the Red River, no monitor wells were constructed in the lower part of Goathill Gulch.

Wells MMW-2 and MMW-3

Well MMW-2 (in valley-fill) and MMW-3 (in bedrock) were drilled in the fan delta area in lower Capulin Canyon. Figure 7 is a cross-section illustrating the hydrogeologic relationships at MMW-2 and -3. Water-level elevations of these two wells are 90 to 100 feet above the level of the Red River at the mouth of the canyon. These elevations, if connected to a stream bed elevation farther upstream, are indicative of gaining conditions along the Red River. Based on the number of springs and seeps issuing from cutbanks along the river, the water table is likely to be at the stream bed. There is a weak upward gradient from the bedrock to the valley-fill; however, the water quality of the valley-fill ground water at MMW-2 is much closer to that of the surface flow in lower Capulin Canyon than to the water quality of the bedrock ground water. It also appears that the seeps near the confluence of Capulin with the Red River contain water that is chemically more similar to the valley-fill than the bedrock. Lower Capulin Canyon may be outside the influence of the dewatering at the mine.

Water Levels and the Red River

A number of the monitor wells show water-level elevations at or slightly below the elevation of the river opposite the well. Construction of a water-level contour map using data collected in November 1994 from both the valley-fill and bedrock wells (head elevations are very close for paired bedrock and valley-fill wells) revealed a cone of depression configuration that included MMW-8A and -8B, MMW-11, and MMW-13. Monitor wells MMW-10A, -10B, and -10C were considered to be outside the cone and related to a water table at or very close to the elevation of the stream bed.

A preliminary potentiometric water-level map (Figure 8) shows a cone of depression centered above the underground mine. (The southern edge of this cone is being monitored by the newly constructed wells.) A schematic of water-level changes in the area of the underground mine is shown on Figure 9.

3.3 AQUIFER TESTING

An aquifer test was conducted at MMW-10A at a pumping rate of 140 gpm (the pump was not capable of a higher rate). Although drawdown and recovery tests were completed at this rate, the valley-fill aquifer was not stressed. The drawdown leveled out after 10 minutes of pumping at 10.5 feet, indicating recharge balanced discharge. Transmissivity calculated from the aquifer test was considerably higher (123,200 gallons per day per foot - gpd/ft) than that calculated from the recovery test (32,139.1 gpd/ft). Recharge during the aquifer test strongly reduced the drawdown. The hydraulic conductivity from the recovery results is about 300 gallons per day per square foot (gpd/ft^2), which is in the range of values reported for sandy gravel. During the aquifer tests, water levels were monitored at MMW-10B and MMW-10C. Water level declined 6.0 feet in the bedrock well (MMW-10B), which suggests that the fractured bedrock below the valley-fill is in hydraulic continuity with the fill accounting for a common water level. The continuity between the water-level at MMW-10C and the other wells was thought to indicate continuous saturation from MMW-10C (total depth 58 feet) and the deeper wells. MMW-10C did appear to experience some drawdown (less than 1 foot), and it is possible that the change in depth-to-water at MMW-10C was a function of changes in barometric pressure. A perched zone above a clay unit may underlie MMW-10C (with a water table independent of the deeper saturated zone). However, the clay may have considerably reduced any response from the shallower well at MMW-10A. Our interpretation is that the latter is correct and saturation extends across all three wells.

Data from the aquifer testing are presented in Appendix E.

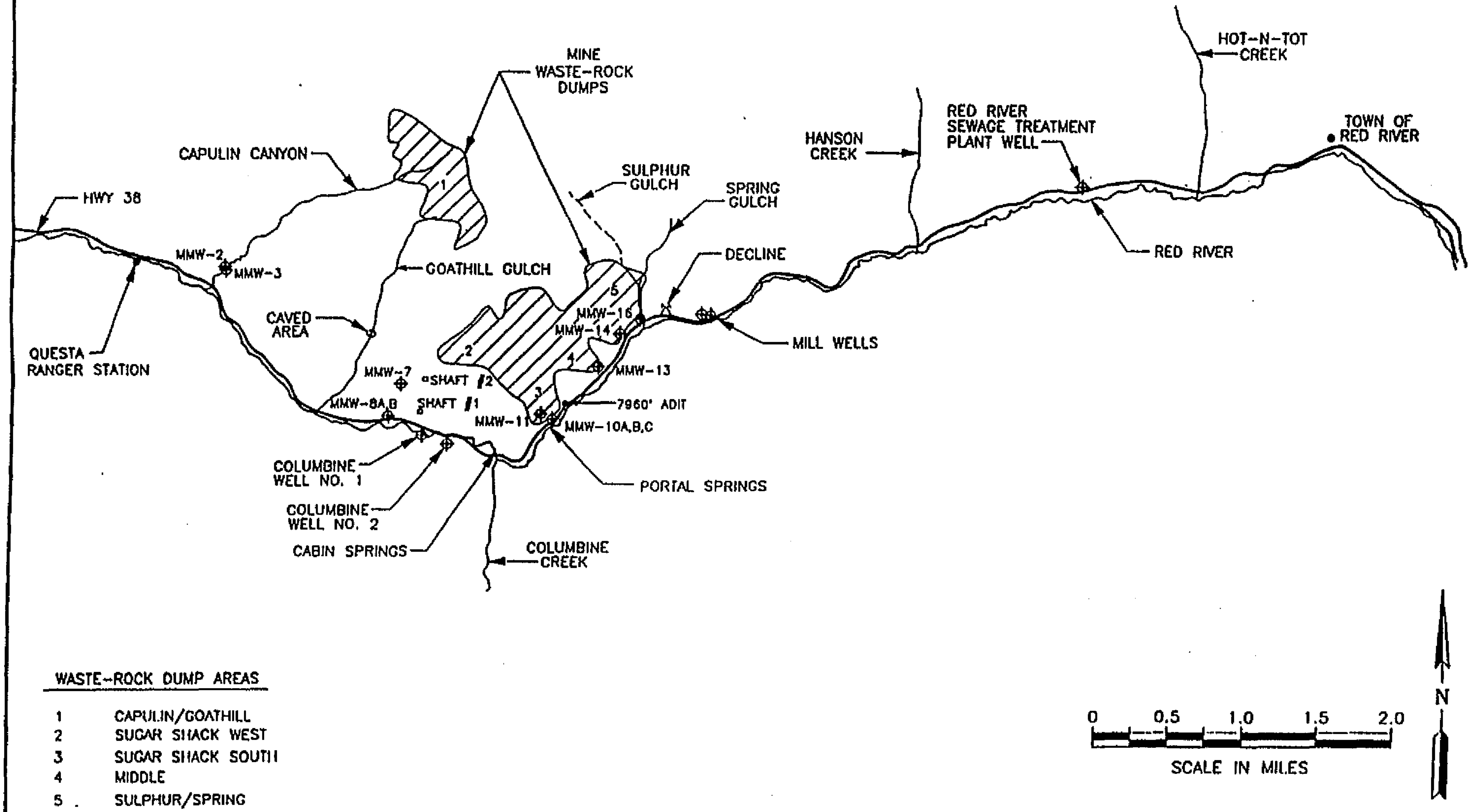
3.4 WATER QUALITY

Table 1 presents the results of the most recent water quality sampling (Fall 1994) for monitor wells located in the Mine Area. Table 2 illustrates selected chemical parameters for the wells and the seep. Water-quality data are provided in Appendix D. [Note: Water from the Portal Springs seep was sampled in May 1994; the other well samples were collected in November 1994].

The chemistry of the monitor well water and river seeps is site-specific. Three river seeps of concern are the Portal Springs seeps, Cabin Springs seeps, and Capulin Canyon seeps. At both Portal Springs and Capulin Canyon, the seep water appears to be more closely aligned (based partly on pH) to ground water in the valley-fill than the underlying bedrock aquifer. Ground-water samples from all of the Mine Area monitor wells have TDS and sulfate concentrations above the concentrations in the Red River. A detailed discussion of water quality is presented in Appendix D.

Artificial Seepage Conduits

A gas-line utility trench parallels State Route 38 and is a potential lateral conduit for seepage either at the water table (Portal Springs) or possibly from perched zones near the river. If these trenches are carrying seepage, the discharge zone to the river might be considerably lengthened.



WASTE-ROCK DUMP AREAS

1	CAPULIN/GOATHILL
2	SUGAR SHACK WEST
3	SUGAR SHACK SOUTH
4	MIDDLE
5	SULPHUR/SPRING

FIGURE: 2

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95	J.C.K	M.O'M.

MINE AREA SITE MAP

Molycorp, Inc.
Questa, New Mexico

XSEC-MAP

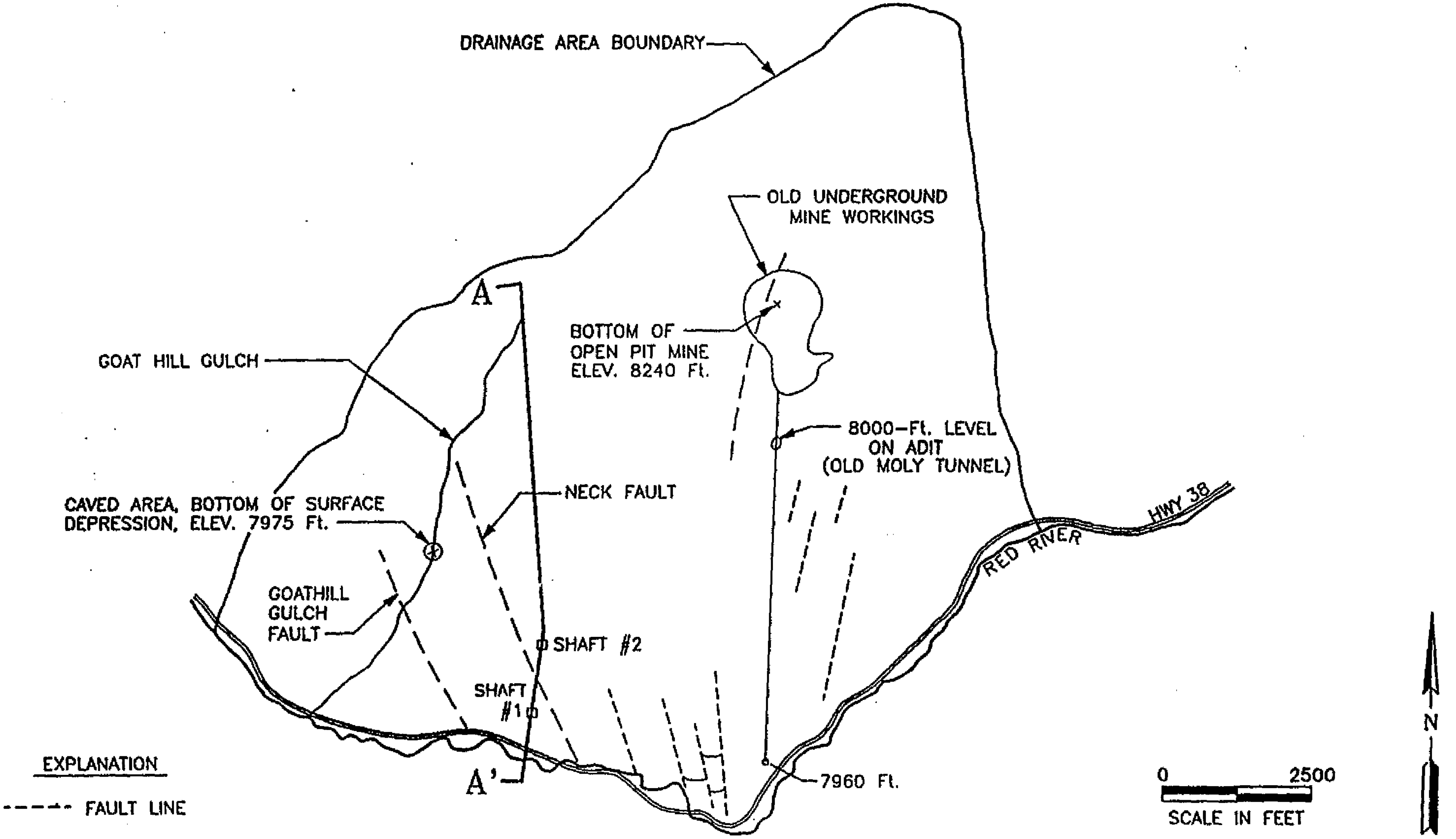


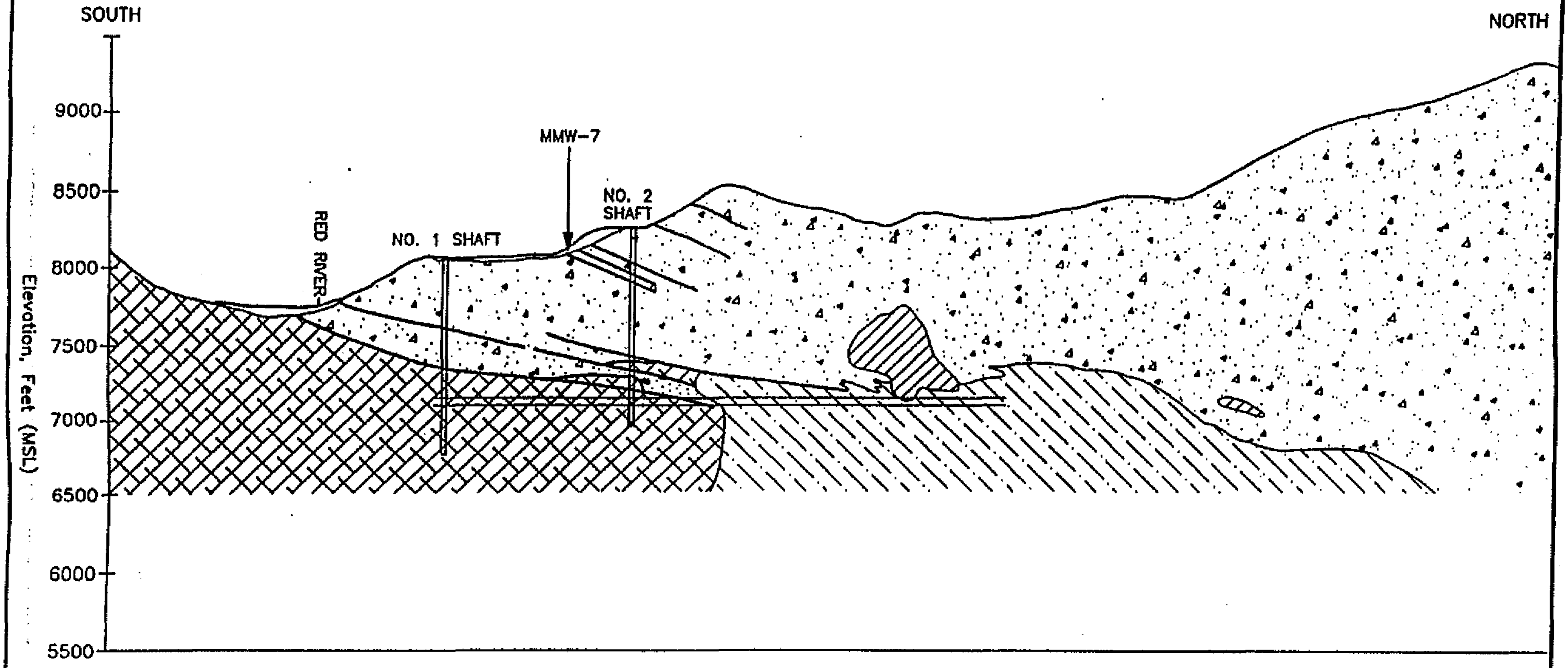
FIGURE: A2

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

APPROXIMATE CROSS-SECTION LOCATION

Mine Area – Molycorp, Inc.
Questa, New Mexico



LEGEND

▨ MINERALIZED ZONES

▧ TERTIARY INTRUSIVE: MINE APLITE AND GRANITE

░ TERTIARY VOLCANICS: FLOWS, TUFFS, DIKES

▩ PRECAMBRIAN ROCKS

— LOW-ANGLE NORTH-DIPPING FAULTS

SEE FIGURE A2 FOR CROSS-SECTION LOCATION

0 500 1000

VERTICAL & HORIZONTAL SCALE IN FEET

FIGURE:	SOUTH PASS RESOURCES, Inc.				GEOLOGIC CROSS-SECTION A – A' Mine Area – Molycorp, Inc. Questa, New Mexico
3	PROJECT No.: 001-06	DATE: 4/21/95	AUTHOR: JCK	DRAWN BY: M.O'M.	

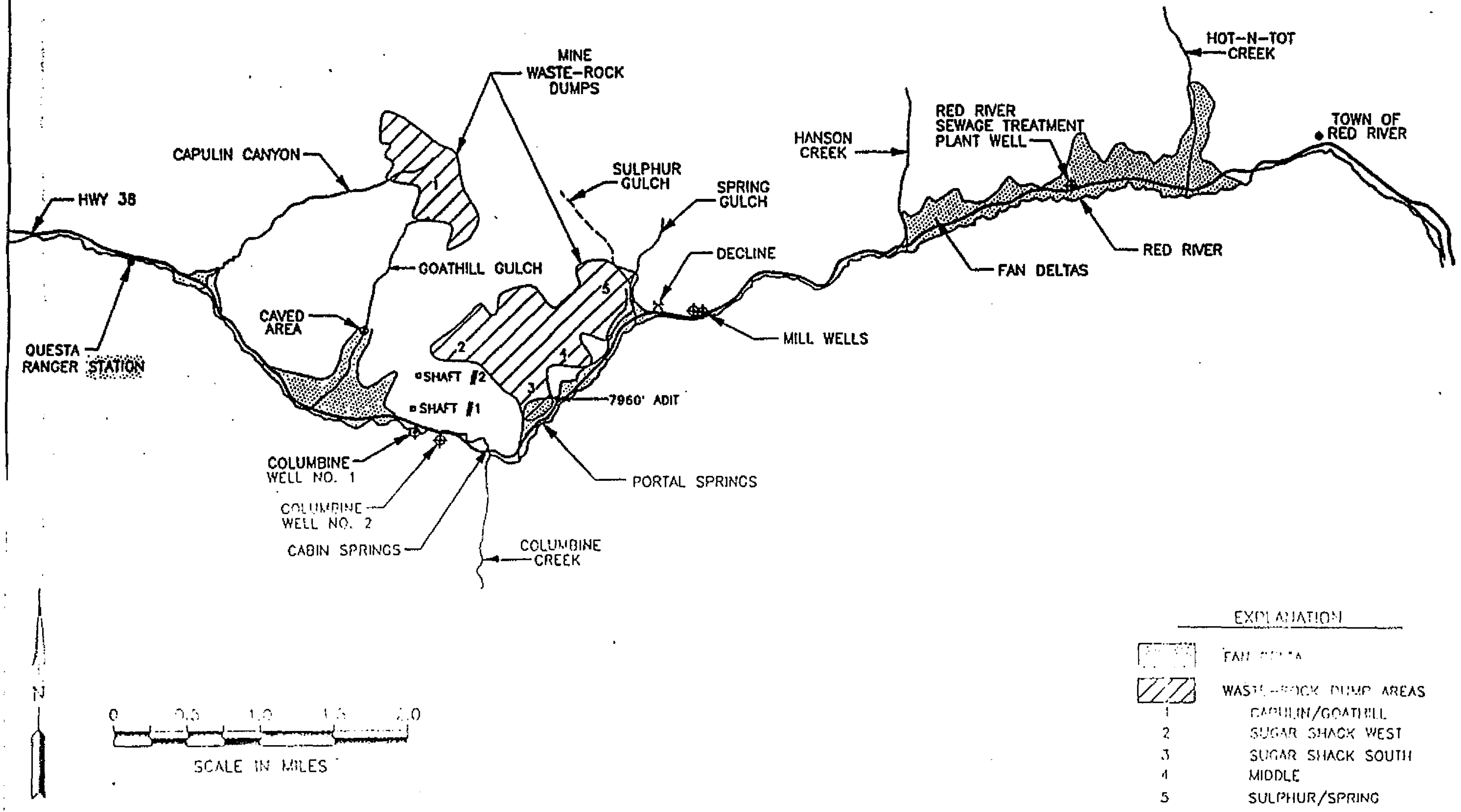


FIGURE: 4

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95	J.C.K	M.O'M.

FAN DELTA AND MINE WASTE-ROCK LOCATIONS

Molycorp, Inc.
Questa, New Mexico

XSEC-19

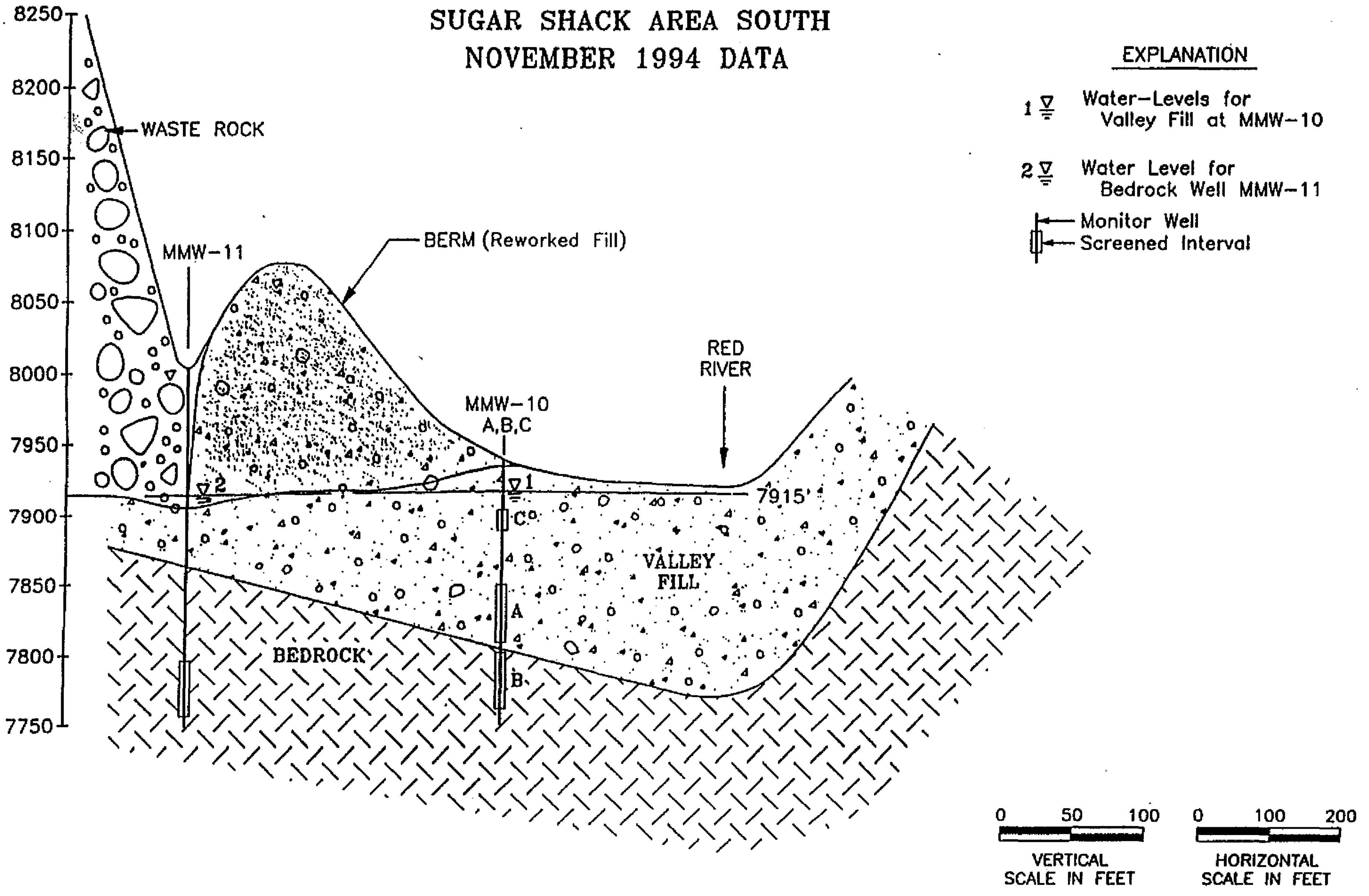
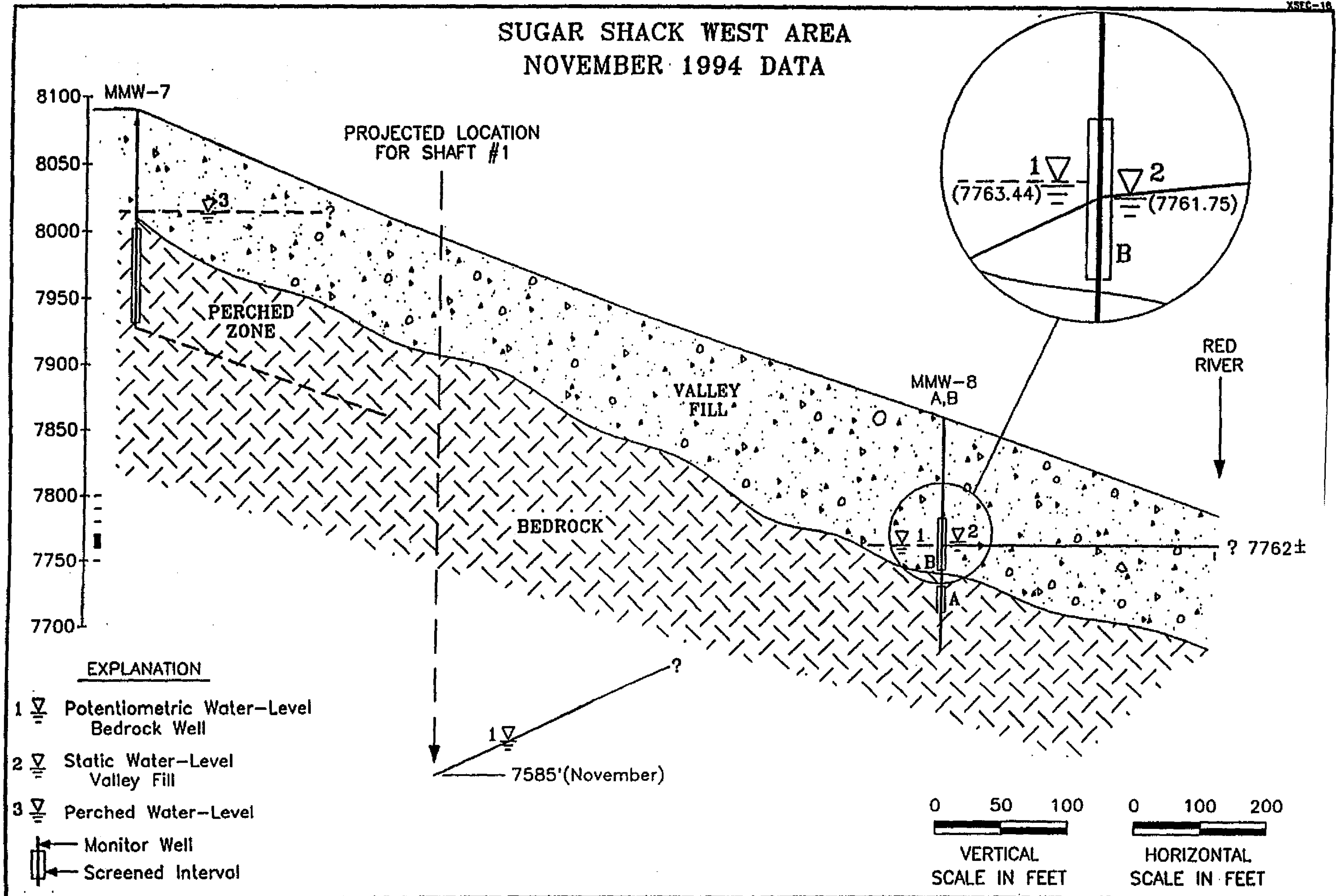


FIGURE: 5	SOUTH PASS RESOURCES, Inc.				HYDROGEOLOGIC CROSS-SECTION, SUGAR SHACK SOUTH Mine Area - Molycorp, Inc. Questa, New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

XSEC-16

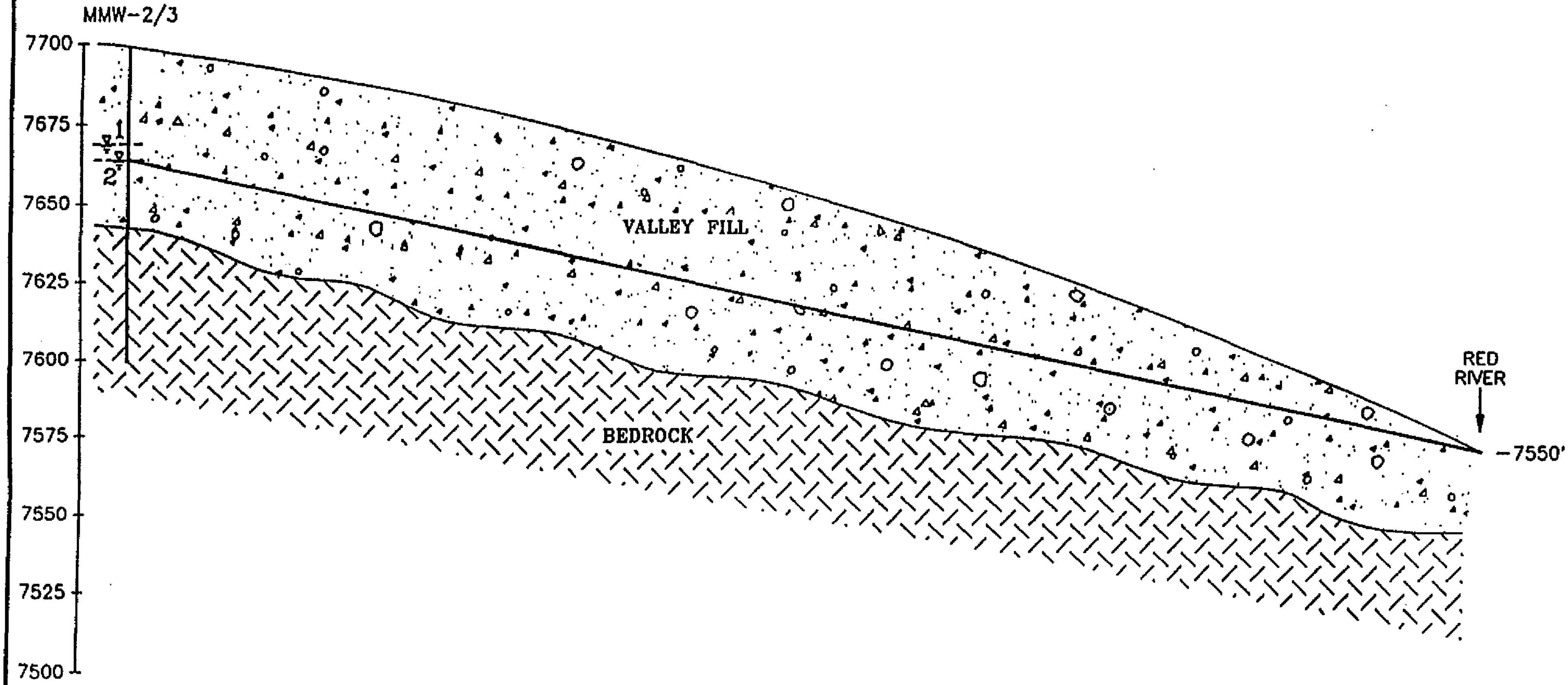


SUGAR SHACK WEST AREA
NOVEMBER 1994 DATA

FIGURE: 9	SOUTH PASS RESOURCES, Inc.				HYDROGEOLOGIC CROSS-SECTION, SUGAR SHACK WEST Mine Area - Molycorp, Questa New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

XSEC-17

CAPULIN CANYON



EXPLANATION

▽ 1 POTENTIOMETRIC WATER-LEVEL FOR BEDROCK WELL MMW-3

▽ 2 STATIC WATER-LEVEL FOR VALLEY FILL WELL MMW-2

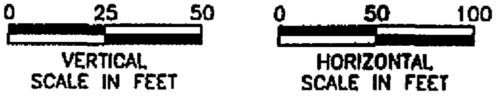


FIGURE: 7

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

HYDROGEOLOGIC CROSS-SECTION, CAPULIN CANYON
Mine Area - Molycorp, Questa
New Mexico

SITE103

RED RIVER CANYON

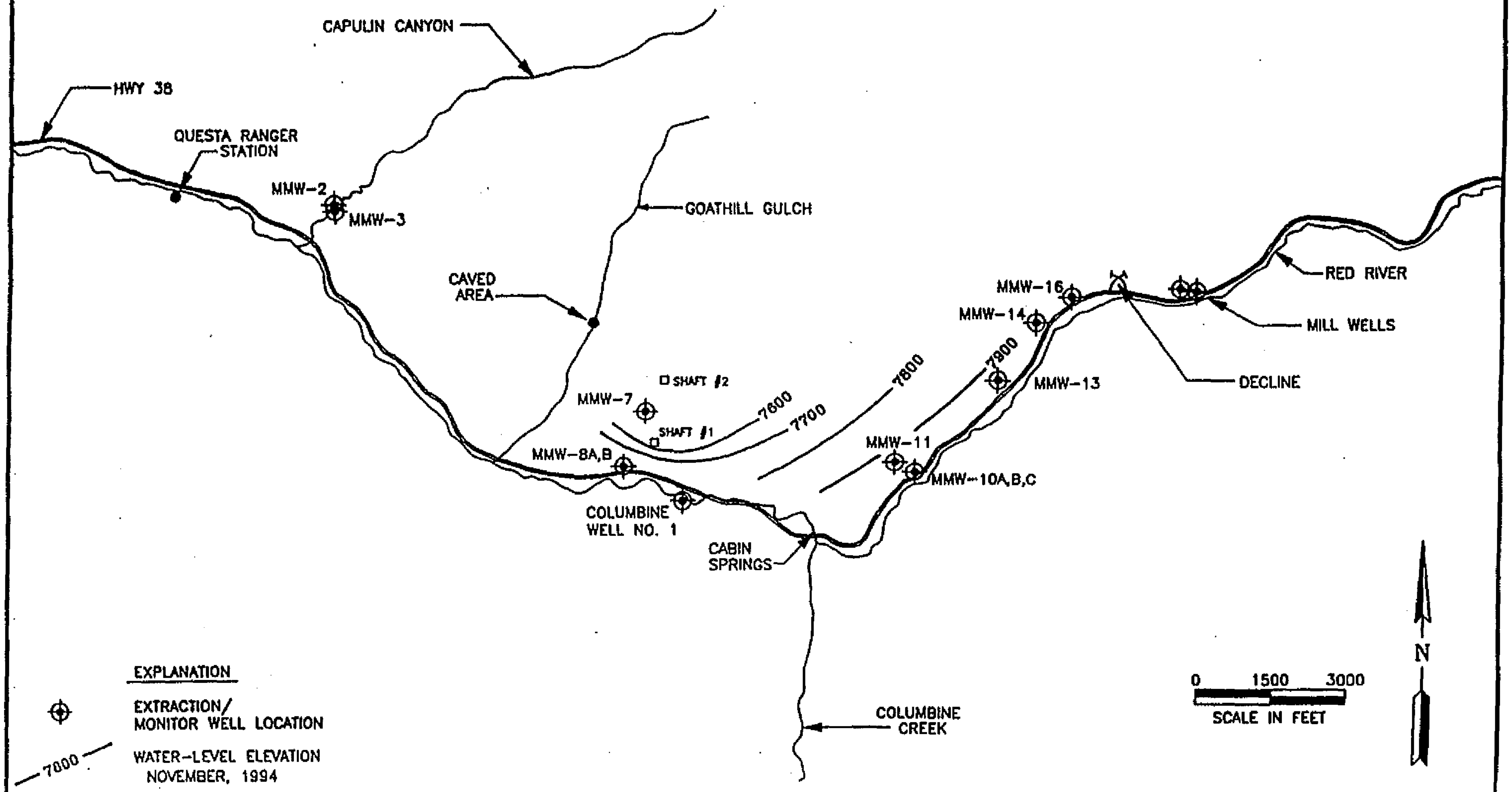
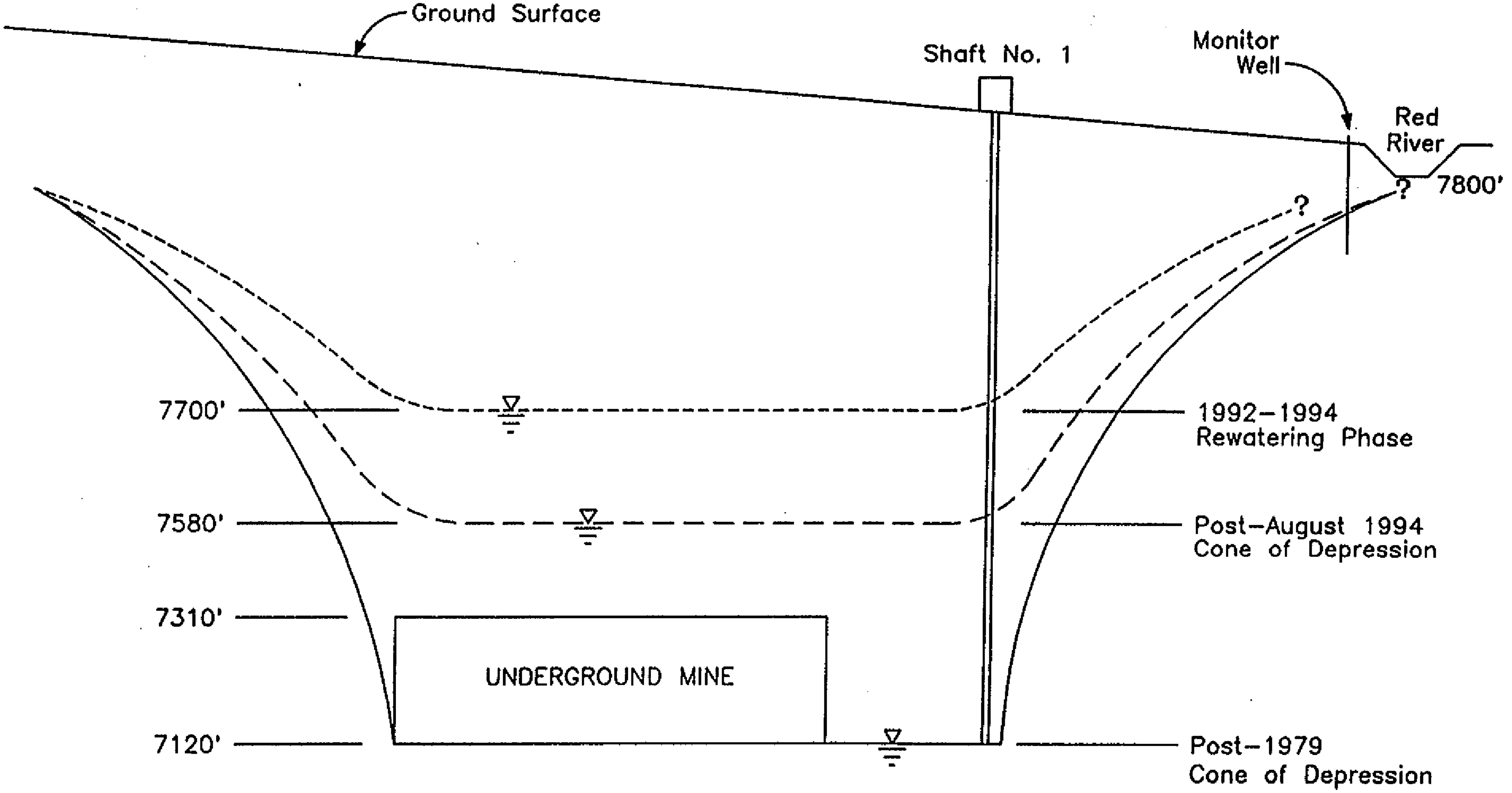


FIGURE: 8	SOUTH PASS RESOURCES, Inc.				GROUND-WATER CONTOURS FOR BEDROCK WELLS Mine Area – Molycorp, Questa New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

XSEC-21



NOT TO SCALE

FIGURE: 6	SOUTH PASS RESOURCES, Inc.				SCHEMATIC OF WATER–LEVEL CHANGES IN AREA OF THE UNDERGROUND MINE MIne Area – Molycorp, Inc., Questa, New Mexico
	PROJECT No.: 001–06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

Monitor/Extraction Wells Installed in Mine Area July/August 1994			
Well No.	Total Depth (feet)	Screened Interval (feet)	Well Completed In
MMW-2	68	38 - 58	mudflow
MMW-3	145	65 - 115	andesite bedrock
MMW-7	161	86 - 161	andesite bedrock
MMW-8A	161	125 - 161	andesite bedrock
MMW-8B	129	67 - 117	mudflow
MMW-10A	144	79 - 130	alluvial gravel/ sand overlying quartz monzonite bedrock
MMW-10B	189	133 - 189	quartz monzonite bedrock
MMW-10C	50	31.5 - 50	mudflow
MMW-11	185	145 - 185	quartz monzonite bedrock
MMW-13	148	105 - 148	sandy gravel, gravelly sand overlying quartz monzonite
MMW-14	75	48 - 75	sandy gravel gravelly sand
MMW-16	98	45 - 98	sandy gravel gravelly sand overlying light grey granite

Other Wells Located in the Mine Area (Partial Listing)		
Well No.	Total Depth (feet)	Year Installed
Mill Well 1A-1	176	1977
Mill Well No. 1	150	1962
Columbine No. 1	89	1965
Columbine No. 2	140	1965
Columbine No. 1 redrill	153	1971

APPENDIX D

Water quality results from 1994 sampling at Molycorp mine, excerpted from SPRI Report, April 21, 1995.

APPENDIX D

Mine Area 1994 Water-Quality Results

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APPENDIX D

Mine Area 1994 Water-Quality Results

Following the Fall 1994 installation of the 12 new monitor wells in the Mine Area, water samples were collected to measure temperature, pH, and conductivity and to analyze for carbonate, bicarbonate, hydroxide, total alkalinity, chloride, fluoride, and sulfate. Monitor well locations are shown on Figures 2 and 10 (main text). Red River and seep sampling locations are shown on Figure D1. Water quality results are provided in Table D1 (Monitor Wells), Table D2 (Red River: May 1994), Table D3 (Red River: October 1994), Table D4 (Mine Water), and Table D5 (Production Wells). The monitor-well data were collected in November 1994, the surface-water data in May and November 1994, and the underground mine and production well samples were taken earlier in the spring of 1994. Temperature, conductivity, and pH were recorded in the field prior to collecting the samples. Because of the low yield (less than 1 gallon per minute) typical of many of the monitor wells, a bladder pump was used to collect the water samples. Temperature, conductivity, and pH were measured at each well until these parameters stabilized (succeeding measurements differed by less than 10%) before sampling.

A precipitation sample was collected in August 1994 near the mill in the Mine Area. The pH of this water was 4.78. Thus, the natural recharge related to precipitation in the mine drainage basin is acidic.

For purposes of comparing a selected set of water samples, the milligrams per liter (mg/L) values have been converted to milliequivalents per liter (meq/L) on the STIFF diagrams. The conversion accounts for differences in weights and electrical charges among the cations and anions. The meq/L values have been plotted on Figures D2, D3, D4, D5, D6 and D7 as STIFF Diagrams in order to facilitate comparisons between water from different sources. The pre-May 1994 water chemistry does not cover the full spectrum of ions included in the later studies and cannot be illustrated on the STIFF Diagrams. The STIFF Diagram has been used in a conventional mode to classify the water sample (such as calcium sulfate water, sodium bicarbonate water) and also as a device to illustrate differences between samples based on a selected set of metals and of anions (fluoride and sulfate). Each sample site has a conventional STIFF diagram for the purpose of characterizing the general chemistry of the water (Na+k, Ca, Mg, Fe, Cl, HCO_3, SO_4, and CO_5) and a second diagram based on selected metals and anions (Al, Mn, Fe, Zn, F, and SO_4).

D.1 Seepage Water Quality

Mine Waste-Rock Dump Seeps: Seepage water from the mine waste-rock dumps is represented by samples CCS-1 (Table D2 and Figure D1) and GHS-1 (Table D2), which plot on the conventional diagram (Figure D2) as magnesium sulfate waters. Calcium and iron are fairly high in these samples. These are acidic waters with pH of 3.0 and 2.0 and total dissolved solids (TDS) of 24,950 mg/L and 23,390 mg/L, respectively. The major dissolved metal is aluminum followed by iron, manganese and zinc in lower concentrations.

Bedrock Seeps: Two samples were collected from natural seeps outside of the Mine Area (HTS-1 and HCS-1: Table D2) and two samples from seeps within the mined area (GHS-1 and CCS-3: Table D2). The natural seeps outside of the Mine Area are highly acidic and have moderate to high TDS values (No. 10: pH 2.86, TDS 2,610 mg/L; No. 22: pH 2.5, TDS 6,493 mg/L). On the conventional diagram (Figure D3), the Hot-N-Tot sample (HTS-1) plots as an iron sulfate water. The Hanson Creek sample (HCS-1) plots as a calcium magnesium sulfate water. Iron is the dominant metal followed by aluminum at Hot-N-Tot, while aluminum followed by iron dominates at Hanson Creek. The concentration of fluoride in the bedrock seeps is less than that in the waste-rock dump seeps. Zinc and manganese are evident in these samples but in much lower concentration than the dump samples.

The bedrock seep at the head of Goathill Gulch (GHS-3: Table D2) is similar to the waste seepage (highly acidic, pH 2.0, and high TDS, 11,980 mg/L). Aluminum (Figures D2b,c) is the dominant metal followed by iron and manganese. This seep is in a highly fractured and altered rhyolitic tuff (clay + quartz + pyrite + gypsum alteration). The outcrop extends beneath the Goathill dump, and its chemistry may reflect a mixture of natural and mine seepage. The second sample (CCS-3: Table D2) was collected from fractured and moderately altered rhyolite in the back of a small adit in lower Capulin Canyon. It is a calcium sulfate water (Figure D2) and has metal concentrations that are considerably lower than the bedrock seep at GHS-3. Aluminum followed by iron and manganese are the significant metal concentrations. It is a moderately acidic water with a moderate TDS of 2,686 mg/L and a fluoride concentration slightly less than sample GHS-3.

D.2 Monitor Well Water Quality

The water quality of well water (Table D1) is best described in terms of specific areas where there may be linkages between sources (dumps, bedrock, valley-fill) and sinks (river seeps). These areas are:

- Middle Waste-Rock Dump (MMW-13)
- Sugar Shack South Waste-Rock Dump (MMW-10A,-10B,-10C, and -11)

- Sugar Shack West Waste-Rock Dump (MMW-7,-8A, and -8B)
- Capulin Canyon (MMW-2 and -3)

Middle Waste-Rock Dump (MMW-13):

The single water sample from the Middle Waste-Rock Dump area is from MMW-13 (valley-fill well) and is characterized as a calcium sulfate water (Figure D4) on the conventional diagrams. It has a high pH of 7.9 and a moderate to low TDS of 1,400 mg/L. Metal concentrations are low.

Sugar Shack South Waste-Rock Dump (MMW-10A, -10B, -10C, and -11):

Based on currently available information, the relationship between Sugar Shack South Waste-Rock Dump ground water (as sampled at MMW-10A, -10B, -10C, and MMW-11) and the Portal Springs seeps along the north side of the Red River is uncertain. Flow directions and hydraulic gradient for the two aquifers can not be evaluated because there are only two wells in each unit. As noted in Section 3.0, water levels for the two bedrock wells are tens of feet above the contact between the valley-fill and the bedrock indicative of an upward gradient as would be expected in a zone of discharge (i.e. the Red River valley).

All of the monitor well water samples would be classified as calcium sulfate (or calcium-magnesium sulfate in the case of MMW-11) (Figures D5a). The pHs are mostly acidic (4.7 to 5.8), except for MMW-10B (a bedrock well) which is alkaline (pH 7.9). The highest TDS for this group of wells occurs at MMW-11 (2,000 mg/L) with the MMW-10 samples in the 1,400 to 1,800 mg/L range. The Portal Springs seep has a higher TDS (2,017 mg/L) than the wells on Figure D5d. In this sample, alkalis (sodium + potassium) and chloride concentrations are elevated compared to the ground-water samples from the wells. Evaporation of these shallow seep waters is the likely cause of these higher concentrations.

The Portal Springs seeps begin about 100 feet west of the MMW-10 wells. These seeps were not noted until January 1993, despite numerous earlier river surveys (Molycorp 1994 communication). The immediate source of the springs is ground water seeping from the valley-fill aquifer exposed along the banks of the river. However, the source of the elevated TDS and sulfate along with fluorine and some metals is not clearly established. Based on the water chemistry and the post-1952 tritium results for MMW-11 (see Section D.2), a possible source is water from the waste-rock dumps infiltrating bedrock and/or valley-fill up-gradient from the wells. Considering that the waste-rock dumps were inplace in the 1970s, the apparent delay in the high TDS and high sulfate water arriving at the river is either the result of a slow travel time (i.e. distant source or low seepage velocity) or seepage was stored in the valley-fill aquifer (precipitation of sulfates, absorption of metals on limonite) later to be released by a change in water chemistry. The water quality from the Red River sewage treatment plant production well may serve as an illustration of ground water impacted by water-rock interactions in a valley-fill. The valley-fill there contains mudflow deposits derived from adjacent hydrothermal scars.

An additional uncertainty is the location of the edge of the original cone of depression during the time the underground mine was in operation in the 1980s. If the cone had extended to the river, seepage from northern sources would have been captured. The succeeding rewatering period may have caused the edge of the cone to migrate northward allowing some seepage to move westward with the ground water. Continued monitoring of water levels and water quality may supply some answers.

Sugar Shack West Waste-Rock Dump (MW-7, -8A, and -8B):

The unnamed tributary canyon that lies just east of Shaft No. 1 could conceivably carry drainage from the Sugar Shack West Waste-Rock Dump and possibly from the east end of the Goathill Gulch Waste-Rock Dump. Monitor well MMW-7 is screened in a pyritic andesite. As indicated in the hydrogeology discussion (Section 2.2 and Appendix B), the andesite in this area is highly fractured along a series of stacked north-dipping low-angle faults. A perched ground-water zone that lies some 500 feet above the cone of depression may be present in the andesite fractures. The water is highly acidic (pH 4.4), has a very high TDS (16,000 mg/L), and is a magnesium-aluminum sulfate water (Figures D6a), similar in this respect to the waste-rock seepage at Capulin Canyon and Goathill Gulch. Again, like the waste seepage, the water has a very high aluminum concentration followed by elevated concentrations of iron, manganese, zinc, copper, and nickel. Seepage from Sugar Shack West or east Goathill Gulch Waste-Rock Dumps could contribute to the water chemistry, but such a linkage has not been established at this time. The perched zone may be close enough to the surface to be impacted by leachate from oxidizing vadose water.

Perched zones of this type may occur elsewhere in the Mine Area. Similar sites of low-angle north-dipping faults that are offset by north-trending high-angle faults occur in the bedrock exposure above Cabin Springs. A similar perched zone may be responsible for the moderate pH (5.1), moderate TDS (2,040 mg/L), high aluminum (32.7 mg/L) waters that issue from the bedrock seep at Cabin Springs (Figure D6c,d). Fluoride, manganese, and zinc occur in elevated concentrations at this seep.

Water samples from the two monitor wells close to the river and at the downstream end of the unnamed tributary canyon are also calcium sulfate waters (Figure D6) with moderate to high pH (8.2 at MMW-8A, and 6.4 at MMW-8B) and moderate TDS (2,200 and 1,100 mg/L, respectively). Metal concentrations are very low. A strong hydrogen sulfide odor was noted when both MW-8A and MW-8B were sampled in November 1994. This odor suggests the presence of localized reducing conditions related to breakdown of organic chemicals in drilling foam that was not flushed out during development. However, organic matter in the fan delta deposit, or fine organic matter recharged from the river to the well, can not be ruled out. Until more water-level and water-quality data are collected from these wells, their relationship to the cone of depression is uncertain.

Capulin Canyon (MMW-2 and MMW-3):

The water from MMW-2 (valley-fill) is acidic (pH 4.9) with a TDS of 3,400 mg/L. Well MMW-3 (bedrock) water has a higher pH (7.5) but only a slightly lower TDS (2,900 mg/L). Both waters are classified as calcium sulfate waters (Figure D7). The metal concentrations result in different STIFF Diagrams. The aluminum and manganese concentrations are higher in MMW-2 water compared to MMW-3 water (Figure D7a).

The valley-fill well (MMW-2) may be more closely related to the surface flow in lower Capulin Canyon that infiltrates the fill about 1,000 feet up-canyon from the wells. This surface flow (CCS-4: Table D2) has a low pH (4.0), a TDS concentration of 1,192 mg/L, and aluminum concentration of 23.2 mg/L. However, there are some significant chemical differences between the surface seepage at the point where it infiltrates the valley-fill up-gradient from the monitor wells (CCS-4) and the monitor well (particularly MMW-2) chemistry. Manganese, iron, zinc, and copper concentrations are much higher at MMW-2 than at CCS-4. This metals concentration either represents an earlier slug of seepage water or reflects in-situ reactions between the valley-fill rock material and acidic water. The metals STIFF Diagram (Figure D7a) for the Capulin Canyon seep (which occurs along an abandoned river channel just east of Capulin; see CCS-6: Table D2) is similar to the valley-fill well water. On a conventional STIFF Diagram, this seep is a calcium sulfate (Figure D7) water but shows evidence of the effect of evaporation on the shallow surface water (elevated alkalis, chloride, and TDS).

Production well water chemistry: Table D5 illustrates the water chemistry for ground water from wells screened in valley-fill (sewage plant well and Columbine Well No. 2). The sewage plant well is screened in valley-fill near an area of hydrothermal scar material, which is a source of mudflow sediment and which may be interbedded in the valley-fill. This would account for the low pH, high TDS/sulfate, and high iron, manganese, and aluminum content. The Columbine well is screened in river alluvium and is of much higher quality than the tributary waters. The reason for its low pH relative to the river water is not clear.

D.3 Mine Water Quality

Available water chemistry data from samples taken at the shafts and the decline is shown in Table D4. The underground mine waters are significantly more alkaline (higher pH) but lower in metals, sulfate, and TDS compared to seepage waters. Oxygen can reach the underground workings above the rising water table through surface connections (e.g., caved area and decline) and create a thin zone of oxidizing vadose waters which react with the fractured, pyritic rock to produce the TDS and sulfate concentrations. Water levels are probably rising faster than downward infiltration is occurring; therefore, high TDS/sulfate water is incorporated and diluted in the ground water. Once the pyrite-bearing rock in the area of the underground mine is submerged beneath the water table, little oxidation may occur (Frost, 1979), and the ground-water chemistry should be a combination of ambient water quality plus leachate from surface connections. The deep water sample (taken at a depth of 400 feet below the water table) collected at Shaft No. 1 has a chemistry very similar to the shallow sample. This similar chemistry may not be related to vertical dispersion and mixing, but rather to the incorporation of vadose water at an earlier time when the water table was lower than present -- indicating that ground water may be nearly stagnant, enclosed by low hydraulic conductivity rocks.

Acidic, high TDS water enters the ground-water system in the underground mine area through several avenues:

- The vadose zone above the workings consists of fractured (partly mine-induced) and mineralized rock that is a source of such water. Once the workings are submerged, this is no longer a source.
- The caved area developed as the result of the block-caving mining method conducted at Molycorp's deeper mine. The upper part of the caved area consists, in part, of hydrothermally altered rock (pyrite, kaolinite, sericite, and quartz), which is typical of hydrothermal scar material and of unmineralized andestic volcanics (unpublished map, Molycorp). The elevation of the postulated water-table surface across the caved area after recovery from the rewatering of the mine is expected to be at least 7,840 feet (SPRI, 1993b). The elevation of the rim of the caved area is 8,100 feet, leaving 255 feet of fragmented unmineralized volcanic rock and hydrothermal scar material above the water table. It is this material, in the vadose (unsaturated) zone above the water table, that would be subject to more intense oxidation processes.
- Seepage barrier water from Capulin and Goathill Gulch mine waste-rock dumps is discharged to the caved area. Future plans are to pipe this water to the tailings pond area.
- Currently, the underground mine is being dewatered, creating a sink for water from all of the above sources.

D.4 Tritium Isotope Analyses

Tritium is the heavy isotope of hydrogen (^3H) that disintegrates radioactively to helium (^3He) at a half-life of 12.3 years (Mazor, 1991). After 12.3 years, half of the initial amount of tritium has decayed to helium. The concentration of tritium in water is expressed in tritium units (TU), which is a ratio of tritium to hydrogen atoms. The T/H ratio of 10^{-18} is defined as one TU.

Tritium is produced naturally in the atmosphere by the radioactive decay of nitrogen (^{15}N). Tritium atoms are oxidized to water, become mixed with precipitation, and eventually enter the ground-water system. Natural production of tritium introduces about 5 TU to precipitation and surface water. In the saturated zone, water is isolated from the atmosphere and the tritium concentration drops due to radioactive decay.

Using a measured value for tritium and a half-life curve (tritium concentration as a function of time), however, does not lead to a precise age for the ground water. As a consequence of recharge, water accumulates and mixes over time in the aquifer such that the age obtained from tritium data is an average or effective age (Mazor, 1991). Smith and Wheatcraft (1993) refer to this "ground-water age" as an estimate of the subsurface residence time of ground water since it was isolated from the atmosphere and soil gas.

Hydrogen bomb tests which began in 1952 in the northern hemisphere added large amounts of tritium to the atmosphere, completely masking the natural tritium input. The peak of man-made tritium production was in 1963, which was the same year that atmospheric testing was halted by international treaty. Since this testing stopped, the tritium content of precipitation has been declining. The tritium content of precipitation has been measured at a worldwide network of stations since the end of testing. These data are normally presented as concentration curves of the annual weighted average of tritium since 1961. Concentration curves from the network show:

- values in the northern hemisphere that are much higher than those in the southern;
- summer peaks and winter lows related to the annual redistribution of tritium in the atmosphere; and
- significant variance from one station to another in terms of the tritium concentrations.

As noted earlier, due to mixing of recharge waters in the aquifer over time, the age of a ground-water sample is an effective age. Further estimates of an effective age are only valid if it is known that the water is derived from a single source/single aquifer system. If older ground water from a bedrock aquifer were to mix with younger water from an adjacent shallow aquifer, the effective age would only reflect dilution. If the appropriate concentration curve is available (i.e. from a geographically nearby station), and if the sample was collected from a single source/aquifer unit, then an effective age can be assigned. According to Mazor (1991), water that has zero tritium (in practice, <0.5 TU) has a pre-1952 age. Water that has significant tritium concentrations (in practice, >10 TU) is of post-1952 age. Water that has concentrations between 0.5 and 10 TU seems to be a mixture of pre- and post-1952 water.

Water samples for tritium analyses were collected in 1-liter brown glass bottles. No head space was allowed in these samples. Six samples were collected in May 1994 and three in November 1994. All samples were sent to Chempet Research Corporation in Moorpark, California for analysis. The enriched tritium procedure allows for a precision of 0.8 TU. The results of the tritium analyses for the May 1994 sample are presented below. (The results of the November 1994 analyses are discussed in Section 4.0 of the main text of this report.)

Results of Tritium Analyses

Sample No.	Site Description	TU ± 2σ
CCS-1	seepage from the base of the Capulin Canyon mine waste-rock dump	15.1 ± 2.2
CCS-2	fresh water spring, west side of Capulin Canyon	12.3 ± 1.8
CCS-3	bedrock seep in an adit, west side of Capulin Canyon	8.0 ± 1.4
GHS-1	seepage from the base of the Goathill Gulch waste-rock dump	16.7 ± 2.4
GHS-3	bedrock seep on the divide near the head of Goathill Gulch	8.5 ± 1.4
Cabin Springs	seeps on the north bank of the river behind the Cabins	17.5 ± 0.6
MMW-11	bedrock well near Sugar Shack South waste-rock dump	16.9 ± 0.6
MMW-3	bedrock well in lower Capulin Canyon	4.38 ± 0.14

Given that the open pit operation (which was the source of the dump material) began in the late 1960s, the tritium data, supported by water chemistry, indicates most, if not all, of the water collected from the dump seepage at the head of Capulin and Goathill Canyons is derived from the dumps. The values greater than 10 TU for the two waste dump samples indicate post-1952 water. Without the appropriate tritium concentration curve, a more precise effective age cannot be made.

Water from the freshwater spring that flows at 12 gallons per minute (gpm) may also be post-1952, but considering the standard deviation, it could be a mixture of older perched water and post-1952 water. The two bedrock seeps appear to be a mixture of pre- and post-1952 water. In the case of the Goathill Gulch sample, the seep lies several hundred feet below the Capulin/Goathill mine waste-rock dumps and may include older perched water and dump leachate that has infiltrated the bedrock. Likewise, the adit sample may include water from pre- and post-adit fractures (caused by excavation of the adit). The tritium values for these bedrock samples reflect dilution rather than effective age.

The average tritium concentrations for precipitation per year have been collected at various world-wire weather stations since 1961. The weather station closest to the Red River area is Flagstaff, Arizona; however, telephone calls to the Flagstaff weather station and several hydrologists who use tritium data failed to locate such a database. Mazor (1991) illustrates plots of TU against years for several different stations. The nearest station in terms of similar latitude is Hatteras, North Carolina, on the east coast. Although the average tritium concentration curves from the northern hemisphere stations are similar (peaks and troughs roughly correspond and their slopes are similar), the absolute value for TU in any one year varies by an order of magnitude or less depending on station location. These absolute values are related to atmospheric circulation patterns. To obtain a reliable estimate of the significance of the TU values for the mine samples, a station about the same latitude but in the western United States would be preferable.

As an example of the application of tritium results, using the Hatteras data from Mazor (1991), precipitation infiltrating the ground in 1970 would have contained about 75 TU. In the intervening 24 years (1970 to 1994), the tritium would have radioactively decayed, leaving about 22 percent (Mazor, 1991, Figure 10.1) of the tritium retained in a 1994 water sample. Assuming no mixing of older and younger water, there should be about 16.5 TU left in the sample. This value is within the range of the "young" water samples collected in the Mine Area (e.g. CCS-1; GHS-1, Cabin Springs, and MMW-11). If the Hatteras data can be applied here, these results, combined with the water chemistry of these samples, indicate water stored in the waste-rock dumps (constructed in the 1970s) could be a source. However, with the limited amount of site-specific hydrogeological data available, a natural acidic seepage source following a short flow path (from recharge to discharge zone) or traveling parallel to a highly permeable zone (short travel time) can not be entirely ruled out. The relatively high TU value for the spring at CCS-2 may be an example of a short flow path.

Pre-1952 ground water contained about 5 TU. In the intervening 42 years (1952 to 1994), approximately 8 percent of the tritium would be retained which corresponds to 0.4 TU.

If ground water was recharged with pre-1952 water without any subsequent mixing, it should contain about 0.4 TU. Samples such as MMW-3, CCS-3, and GHS-3 or those with results in the 0.5 to 10 TU range are mixtures of young (post-1952) and older (pre-1952) water (e.g. an average value for a mixture of 16.5 TU and 0.4 TU water is 8.45 TU).

D.5 Stable Isotope (Lead and Strontium) Study

Eight water samples from the Mine Area (four from Capulin Canyon, two from Goathill Gulch, one from the Red River, and one from Hot-N-Tot Canyon) were analyzed for lead and strontium isotopic composition (Chempet, 1994). The limited objective of this study was to evaluate if any isotopic differences between natural acidic ground water and acidic mine drainages could be detected. To demonstrate statistically significant differences, a much larger number of samples, taken at different times of the year to assess seasonal effects and from varied geologic settings, would need to be collected. Furthermore, isotopic analyses of bedrock, dump, and alluvial source materials would have to be made to evaluate water/rock interactions and causes for any detected differences.

Both strontium and lead consist of radiogenic and non-radiogenic isotopes. In general, as the result of radioactive decay of the parent element, the radiogenic component increases with time. However, the ratio of radiogenic to non-radiogenic isotopes in any given sample containing lead or strontium is not a fixed value. The value depends on the history of the sample: how much of the radioactive precursor was present in the sample originally and how much of the radioactive element of strontium or lead has been removed from or added to the sample at a later time.

Three stable isotopes of lead (Pb) -- 206 Pb, 207 Pb, and 208 Pb -- are radiogenic and are derived by radioactive decay of 238 uranium, 235 uranium, and 232 thorium, respectively. Another stable isotope, 204 Pb, is non-radiogenic and is used as a reference isotope in the lead system. Strontium (Sr) has four naturally occurring stable isotopes -- 88 Sr, 87 Sr, 86 Sr, and 84 Sr. Only one of these (87 Sr) is radiogenic. It is derived from the radioactive decay of 87 rubidium. The reference isotope is the non-radiogenic 86 Sr, and the ratio of 87 Sr to 86 Sr (87 Sr / 86 Sr) is used in evaluating biogeological processes. The purpose of both lead and strontium isotope studies, other than age of the sample, has been to identify probable source material(s), mixing of water from multiple sources, and, from this, flow paths in a ground-water system.

Isotopic studies which focus on a particular mineral (such as galena from an ore deposit) may result in a very narrow range of ratios (age) which are statistically indistinct. However, when ground water or surface water which has reacted with a greater variety of rock types of different ages and different histories is examined isotopically, the range of values widens and isotopic distinctions may be evident. At Questa, Oligocene to Miocene sedimentary rocks ranging from rhyolite to basalt in composition are intruded by granitic bodies of similar but slightly younger ages. These Tertiary units are variably altered and mineralized. Precambrian metasedimentary rocks and granitic intrusions form a basement complex which is juxtaposed structurally, or in an intrusive relationship, to the Tertiary rocks. The rocks in the Mine Area have clearly had different histories, and isotopic ratios might be expected to vary.

Depending on the length of the flow path and the geology along that path, subsurface water (vadose and ground water) may react with a few or a wide variety of minerals that have different isotopic ratios. These differences may be very small, but the high resolution analyses conducted by Chempet can discriminate between water samples where the lead concentrations are in the parts per billion (at Questa, the lead in the water samples ranged from 0.233 to 6.9 parts per billion). Measurements are at the nanogram level (billionth of a gram). Details of the Chempet procedure, including precision and accuracy, are presented in their report (Chempet, 1994). A copy of the Chempet report is available in Molycorp files.

The results are illustrated in a series of isotope-isotope or isotope concentration covariance plots. Data points are plotted with the analytical error. As noted by Mazor (1991), analytical error (sum of all uncertainty in the measurements) is needed to ascertain which data differ from each other with analytical significance. Only data that differ by more than the analytical error should be regarded as different for purposes of data processing. Analytical difference is not the same as statistical difference. At this point, there are far too few data points to say that any cluster of analytically different samples is statistically different from another sample cluster. Given sufficient numbers of samples, data may form statistically distinct clusters suggesting common chemistry and/or Pb/Sr source. The data may form linear arrays related to mixing of ground water along a flow path (such as a flow path from mine waste-rock dump perched water through bedrock or valley-fill).

Prior to summarizing the results of the analyses, some comments and corrections regarding the nature of some of the samples need to be made. Samples GHS-3 and CCS-3 are referenced on the plots as natural seeps in the Chempet (1994) report. While both samples are bedrock seeps, CCS-3 was taken from fractured rock in an adit and GHS-3 was taken several hundred feet below the Goathill Waste Dump. Both may have a component of mine-related water. Sample CCS-4 is from a surface flow in lower Capulin Canyon and is a mixture of mine and natural sources. It is correctly referenced as a mixture on Figures 1 and 2 in the Chempet (1994) report, but is incorrectly labeled as a natural seep on Figures 3, 4, and 5. Also in this same set of figures, CCS-3 is from a natural seep, but is incorrectly labeled as a mixture. Figures D8 through D12 are corrected figures prepared by SPRI.

Figure D8 (207 Pb/204 Pb plotted against 208 Pb/204 Pb), Figure D9 (208 Pb/204 Pb plotted against 206 Pb/204 Pb), and Figure D10 (206 Pb/207 Pb plotted against Pb concentration) all show the two mine waste-rock dump waters are isotopically distinct from the other samples. When strontium is plotted [Figure D11 (206 Pb/207 Pb plotted against 87 Sr/86 Sr) and Figure D12 (87 Sr/86 Sr against Sr concentration)], the separation of the waste-rock dump waters from other waters is not as clear (CCS-1 is closer to the natural spring CCS-3 than the other dump sample GHS-1). On Figure D11, GHS-1, CCS-1, and CCS-3 cluster together. The Chempet report suggests that the clustering may be due to short-term reactions between ground water and mine-impacted rock material (waste-rock fragments and mine-induced fractures in the adit).

The Hot-N-Tot Canyon sample (HTS-1) is from a highly altered but unmined area of volcanic rocks similar to those at Questa. It appears to be isotopically distinct from all of the other samples including the bedrock seeps at Questa. At this point, it is not known whether the difference is the result of a mixing of mine waters with natural acidic seeps at Questa or reflects a distinctively difference hydrothermal system in the Hot-N-Tot area. On the strontium plot (Figure D12), the Red River sample plots off the diagram because of the influence of the older Precambrian rocks in the Red River drainage basin (high ratio of 87 Sr/86 Sr reflects age).

D.6 Summary of the Water-Quality Studies

Mine waste-rock dump seepage and most of the bedrock seeps (except CCS-2) are acidic waters (pH <4.0) with moderate to high TDS, and high levels of aluminum (Al), iron (Fe), manganese (Mn), and zinc (Zn). On STIFF Diagrams, these seeps are typically calcium and/or magnesium sulfate water, but aluminum or iron can exceed the calcium/magnesium in some samples. The major distinction between seepage water and bedrock seeps is the significantly higher concentrations of sulfate, fluoride, and metals [Al, Fe, Mn, Zn, Cu, and cadmium (Cd)]. Tritium results indicate the waste-rock dump seepage is post-1952 water. Preliminary lead and strontium isotopic results suggest the possibility that dump seepage may have a different isotope signature than natural acidic seeps.

The chemistry of the monitor well water and river seeps is more site-specific. The three river seeps of concern are the Portal Springs seeps, Cabin Springs seeps, and Capulin Canyon seeps. At both Portal Springs and Capulin Canyon, the seep water appears to be more closely aligned (based partly on pH) to ground water in the valley-fill than the underlying bedrock aquifer. At Capulin Canyon, elevated concentrations of iron, manganese, zinc, and copper in the valley-fill water (MMW-2) relative to recent nearby up-gradient sources (CCS-4) and down-gradient river seeps (CCS-5 and -6) suggest that either an earlier (pre-1994) slug of leachate is stored in the fill or acidic ground water is actively leaching minerals in the valley-fill deposit.

All of the monitor well water samples exceed State standards for total dissolved solids (TDS), SO_4, F, and Mn. Wells MMW-7 and MMW-2 exceed standards for Zn, Cd, and Fe. Cadmium is slightly elevated at MMW-10A, MMW-10B, MMW-10C, and MMW-11. The November 1994 sampling shows nickel (Ni) exceeds State standards at MMW-2, MMW-3, MMW-10A, MMW-10B, and MMW-7. Nickel was not included in the May sampling.

Seeps at Portal Springs and Capulin Canyon, like the adjacent valley-fill aquifer, exceed State standards for TDS, SO_4, F, Fe (one sample), Al, Mn, and Zn. Cadmium was not included in the May surface-water survey. Both sites are close enough to the surface that natural oxidizing vadose water could contribute to their chemistry.

The bedrock seepage at Cabin Springs exceeds State standards for TDS, SO_4, F, Al, Zn, Mn, and Cd. As in the case of MMW-7, it is not possible to clearly show that waste-rock dump seepage has contributed to the ground water at these sites. Both sites are close enough to the surface that natural oxidizing vadose water could contribute to their chemistry.

Mixing of river seeps with the Red River water (Vail, Surface Water Chemistry, October 1994; Table D3) indicates that, except for Mn, the seep chemical constituents are diluted well below State standards. From the Portal Springs area downstream to the Questa gauge, Mn concentrations slightly exceed State standards.

There is a limited data set for the underground mine waters. What is available indicates that TDS and SO_4 exceed State standards as does F and Mn. Iron and Al are in very low concentrations suggesting that shallow oxygenated and alkaline ground water may serve as a sink (precipitation) for these metals. Oxygenated vadose water, reacting with fractured and rubbilized pyritic rock on the emergent part of the underground mine and in the caved area, as well as dump seepage captured by the caved area are sources of leachate. The cone of depression prevents this ground water form impacting the river or regional ground water.

The production well at Columbine Creek meets all of the State standards, but the one at the Red River Sewage Treatment Plant does not. This well is screened in a mudflow deposit derived from a large hydrothermal scar area. Water from this well exceeds State standards for TDS, SO_4, F, Al, and Mn.

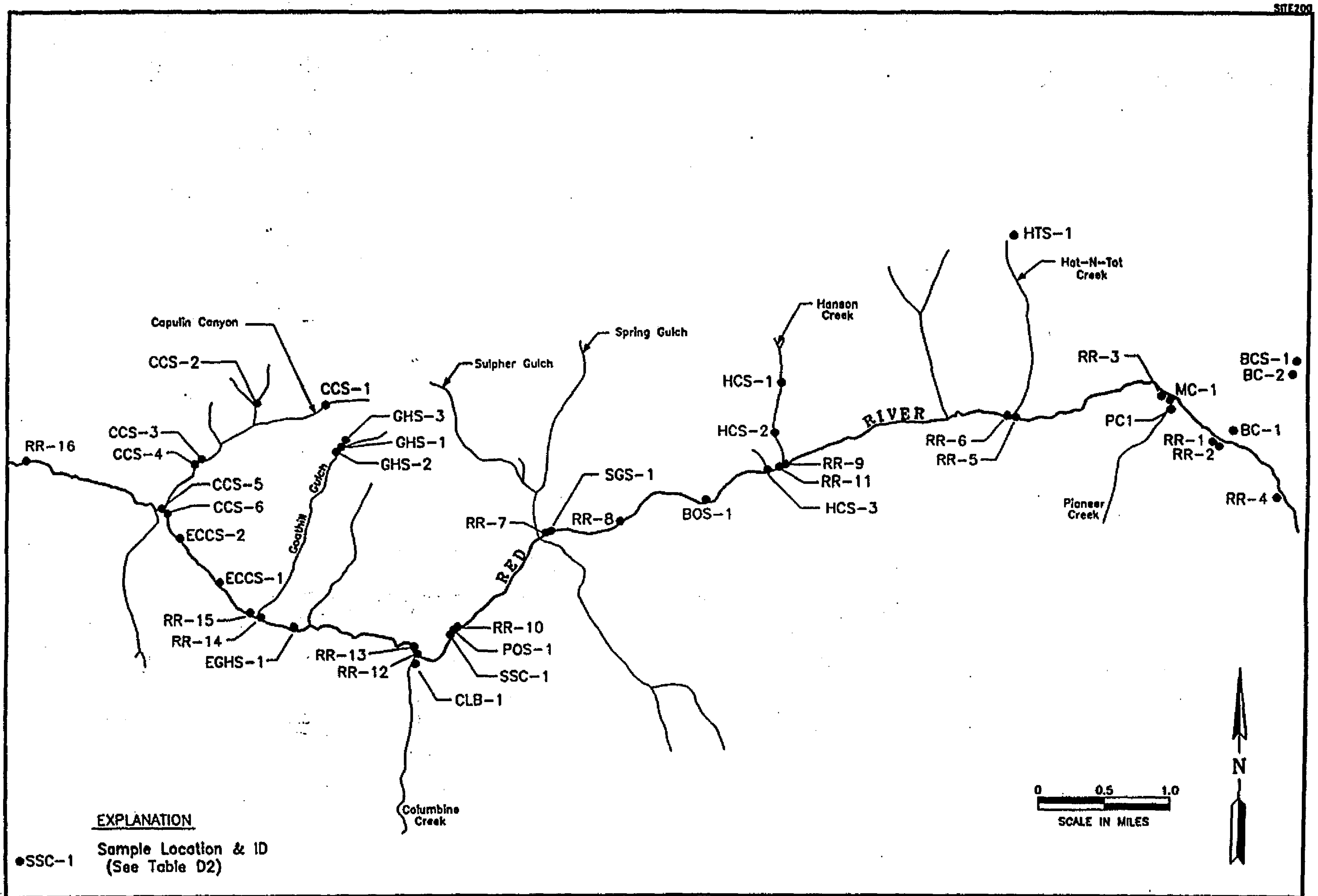
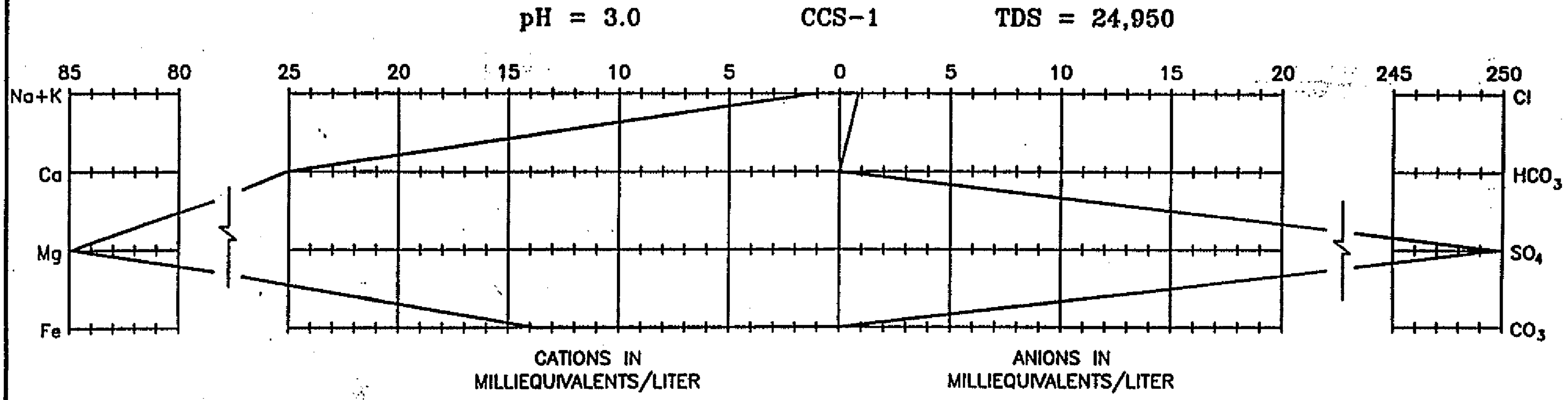


FIGURE:	SOUTH PASS RESOURCES, Inc.				RED RIVER & SEEP SAMPLE LOCATIONS MAY 1994 Mine Area - Molycorp, Inc. Questa, New Mexico
D1	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

STIFF-1


pH = 3.0 CCS-1 TDS = 24,950

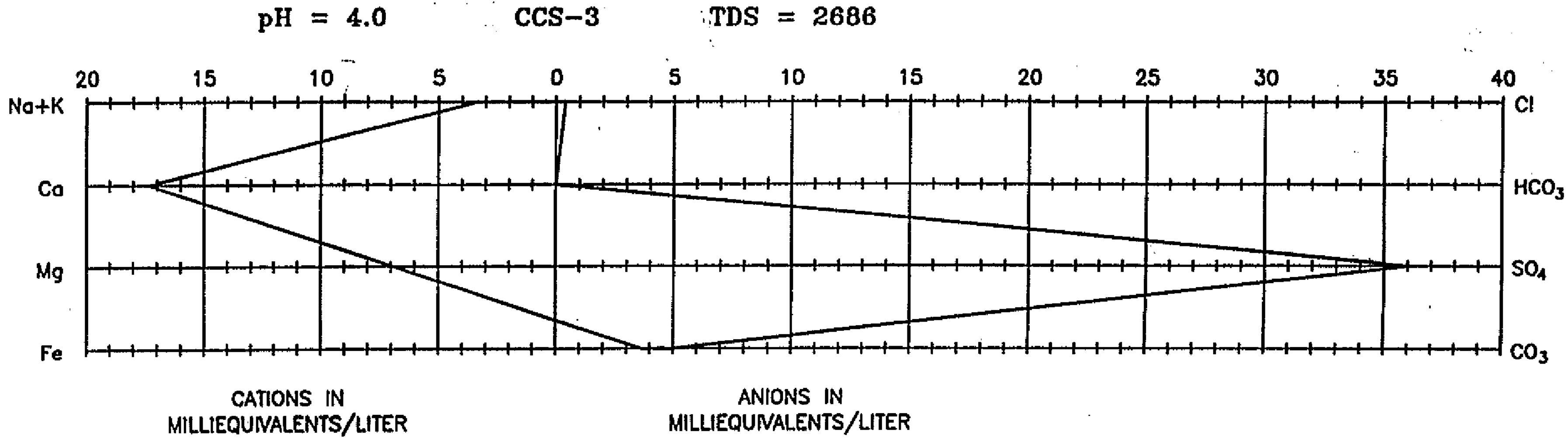
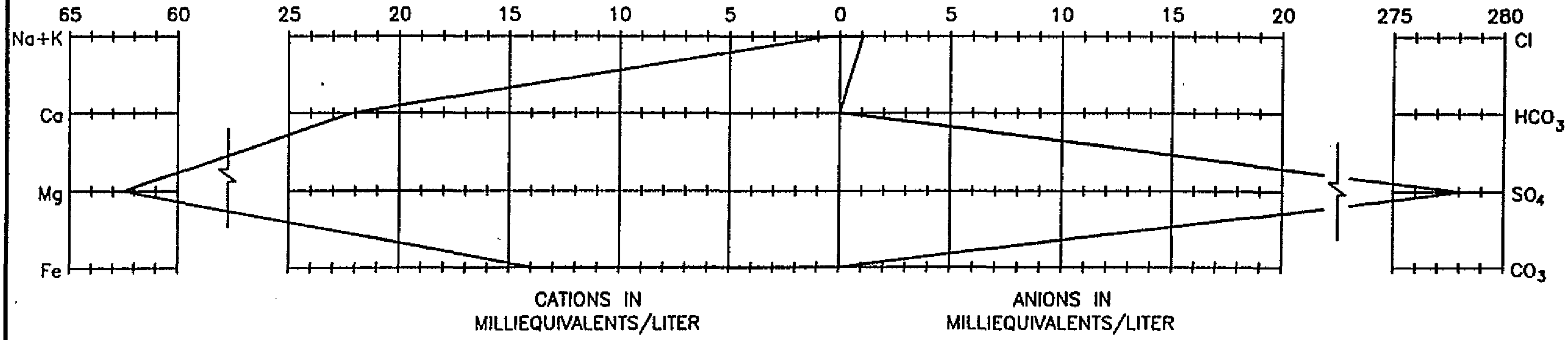

pH = 4.0 CCS-3 TDS = 2686

FIGURE: D2	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS–WASTE ROCK DUMPS AND BEDROCK SEEPS Mine Area – Molycorp, Inc. Questa, New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

STIFF-7

pH = 2.0 GHS-1 TDS = 23,890



pH = 2.0 GHS-3 TDS = 11,980

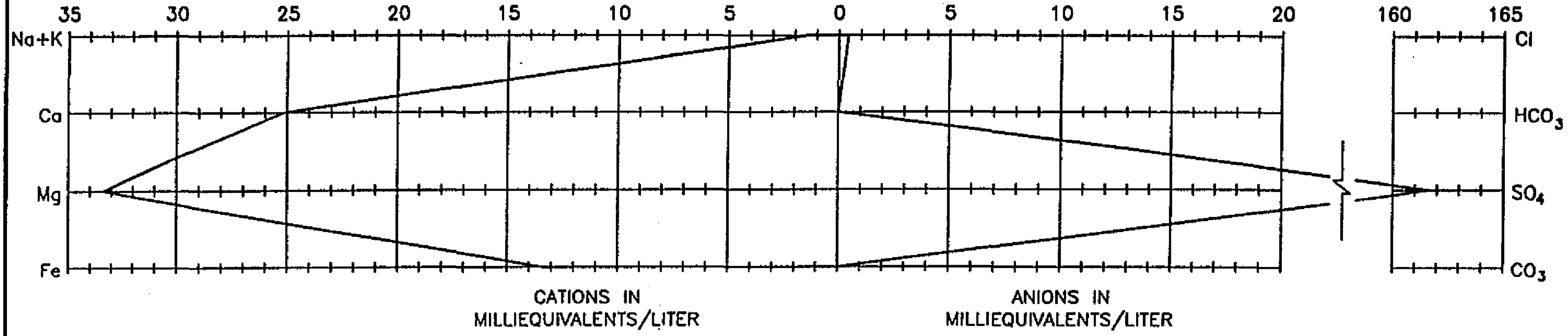
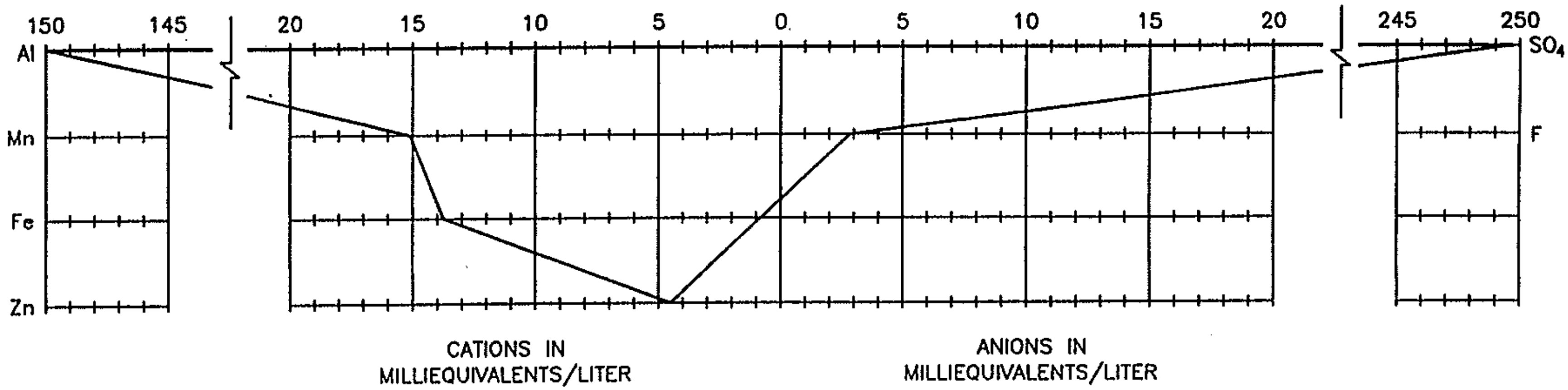


FIGURE:	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS–WASTE ROCK DUMPS AND BEDROCK SEEPS Mine Area – Molycorp, Inc. Questa, New Mexico
D 2b	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

STIFF-1A

pH = 3.0 CCS-1 TDS = 24,950



pH = 4.0 CCS-3 TDS = 2686

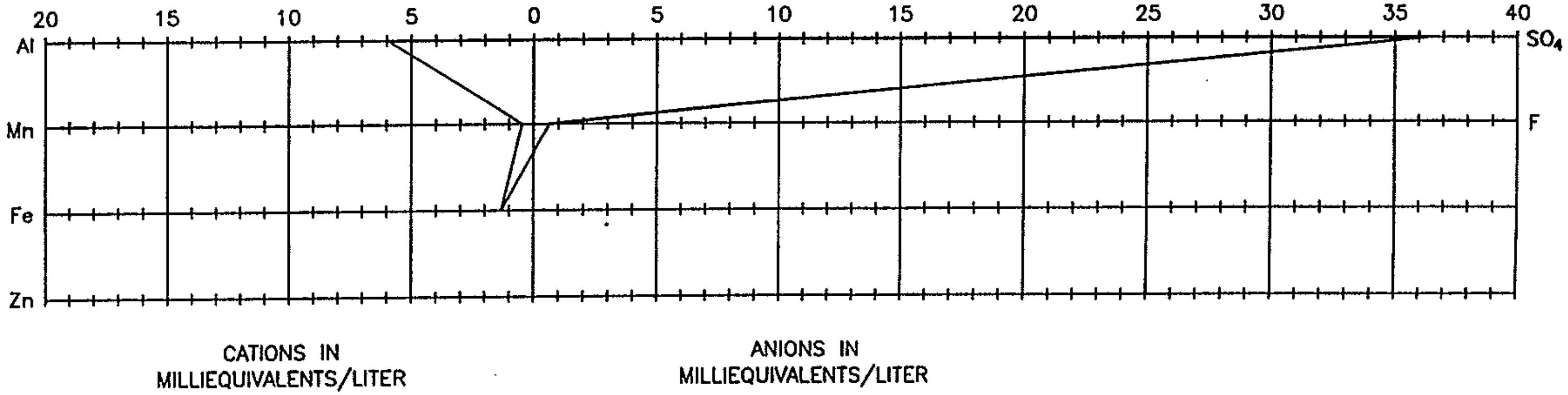


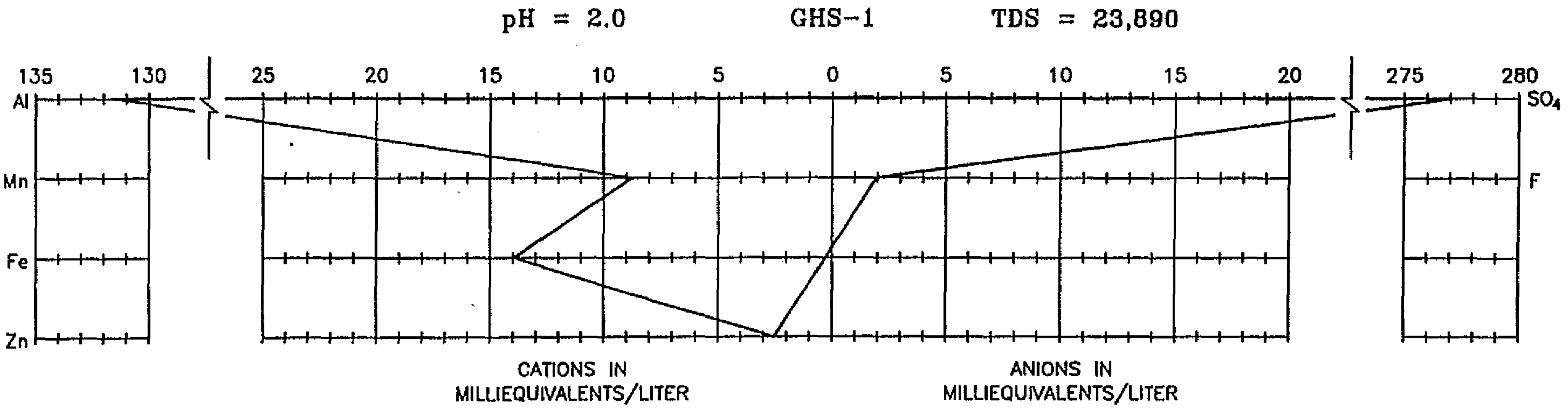
FIGURE: D 2a

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS-WASTE ROCK DUMPS AND BEDROCK SEEPS
Mine Area - Molycorp, Inc.
Questa, New Mexico

STIFF-7A



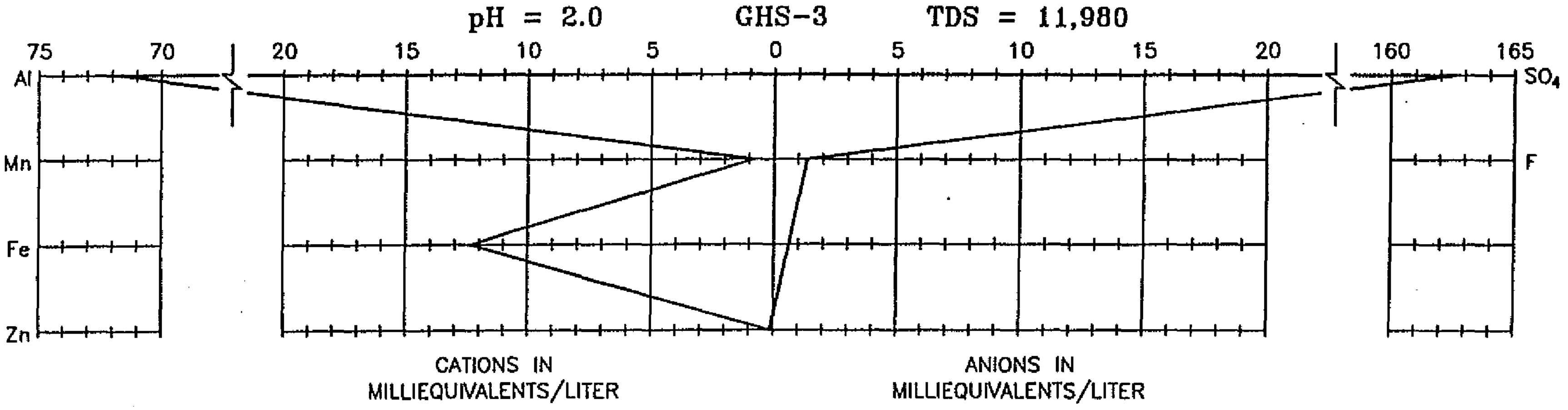


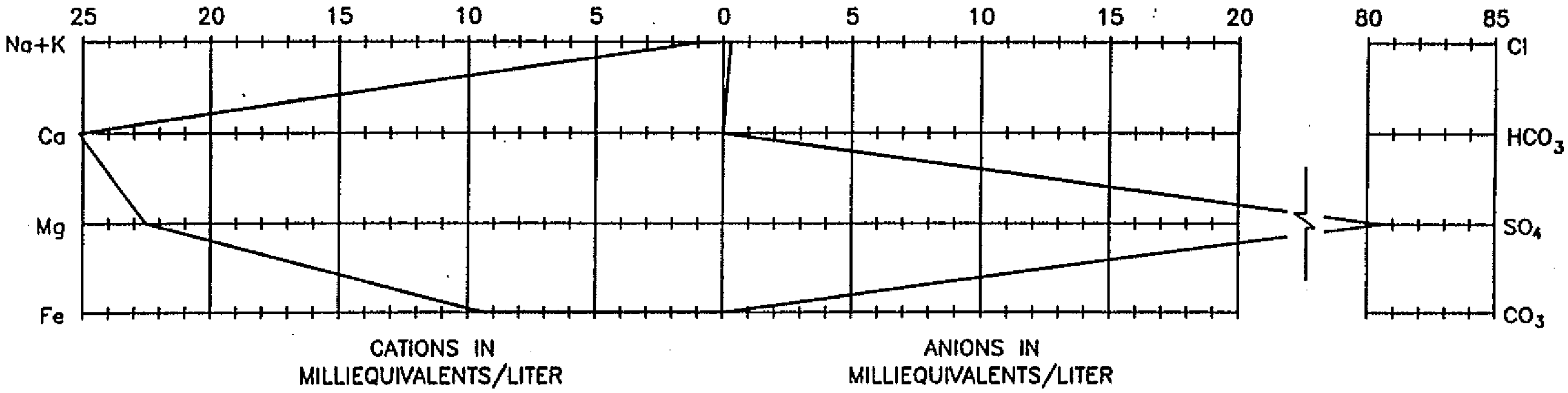
FIGURE: D 2c

SOUTH PASS RESOURCES, Inc.

PROJECT No.: 001-06
DATE: 4/13/95
AUTHOR:
DRAWN BY: M.O'M.

STIFF DIAGRAMS-WASTE ROCK DUMPS AND BEDROCK SEEPS
Mine Area – Molycorp, Inc.
Questa, New Mexico

pH = 2.5 HCS-1 TDS = 6493



pH = 2.3 HTS-1 TDS = 2610

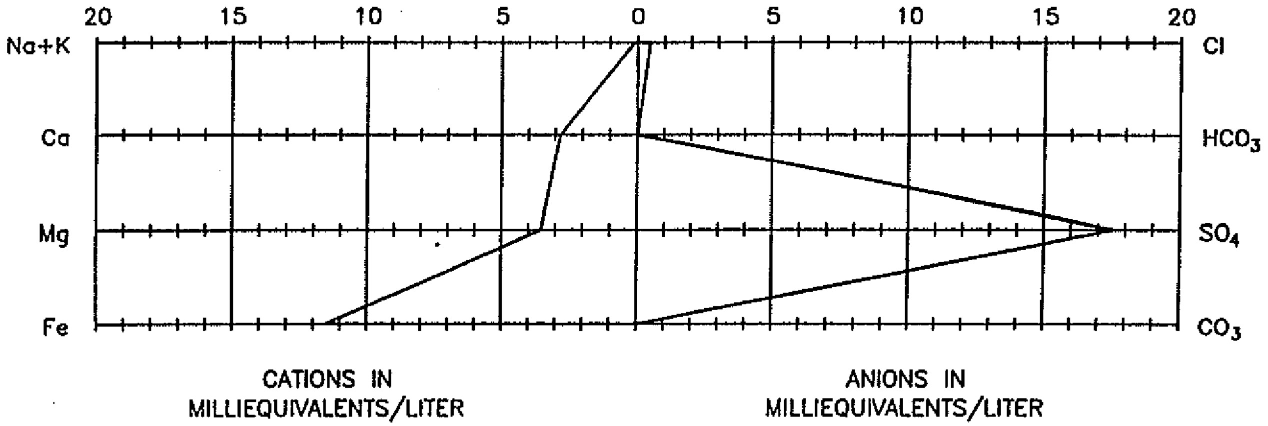


FIGURE: D3

SOUTH PASS RESOURCES, Inc.

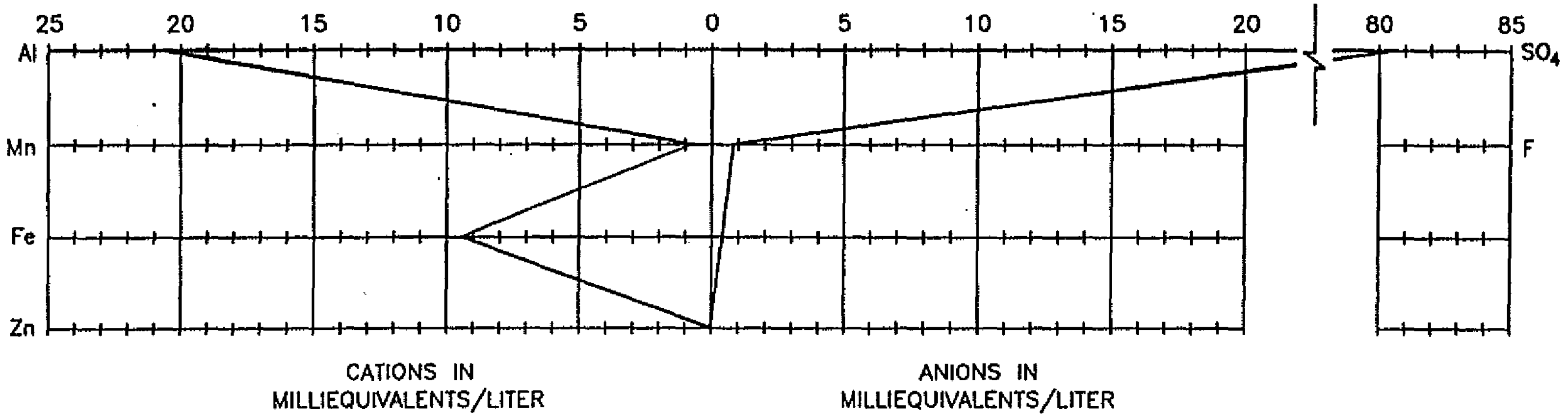
PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS–NATURAL SEEPS OUTSIDE MINE AREA

Mine Area – Molycorp, Inc.
Questa, New Mexico

STIFF-4A

pH = 2.5 HCS-1 TDS = 6493



pH = 2.3 HTS-1 TDS = 2610

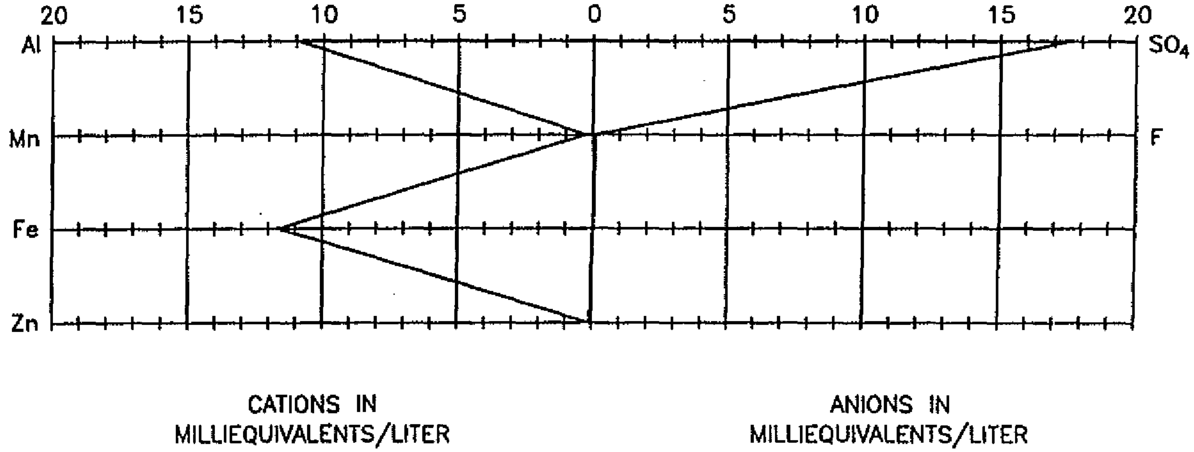


FIGURE: D 3a

SOUTH PASS RESOURCES, Inc.

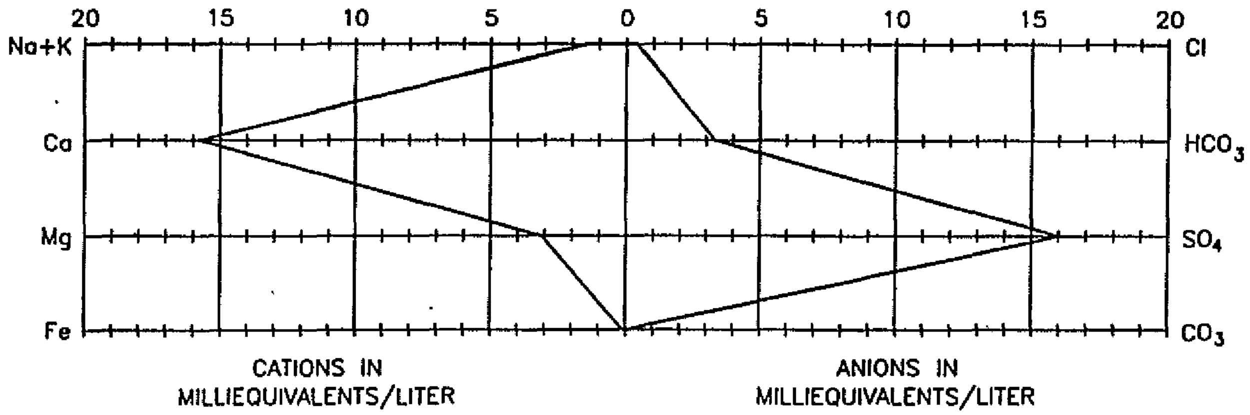
PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS–NATURAL SEEPS OUTSIDE MINE AREA

Mine Area – Molycorp, Inc.
Questa, New Mexico

STIFF-5

pH = 7.9 MMW-13 TDS = 1400



pH = 7.9 MMW-13 TDS = 1400

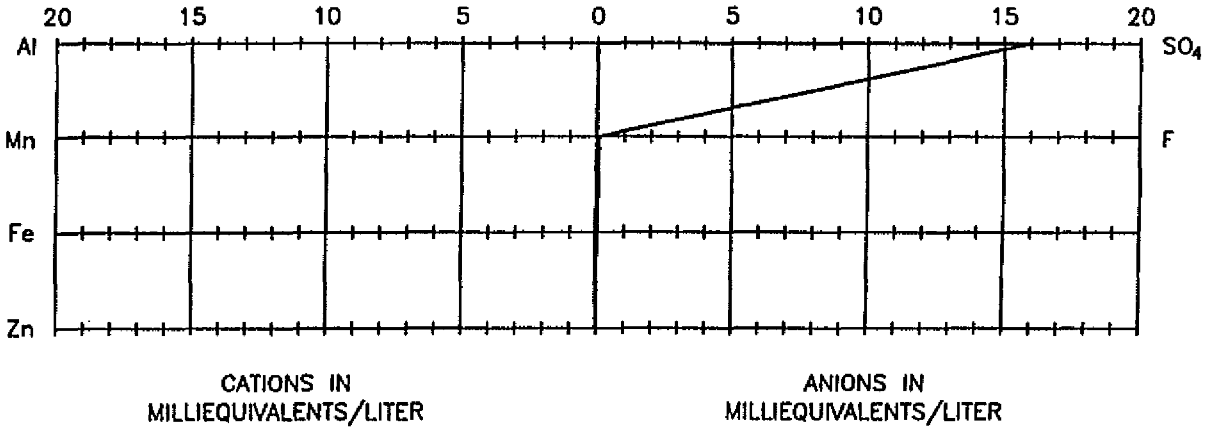


FIGURE:
D4

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAM - MIDDLE WASTE-ROCK DUMP

Mine Area - Molycorp, Inc.
Questa, New Mexico

STIFF-b

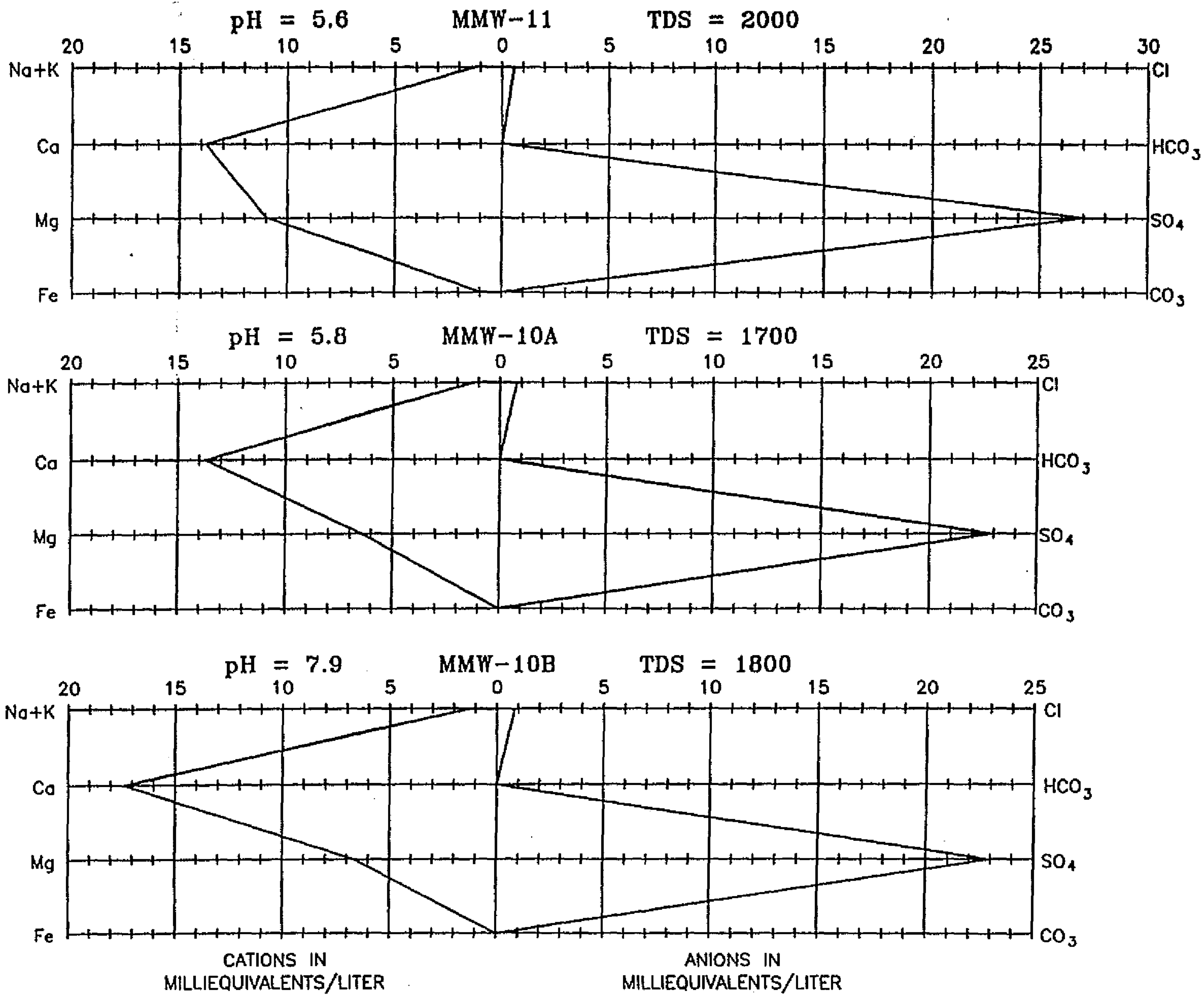


FIGURE: D5

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS - SUGAR SHACK SOUTH AREA

Mine Area - Molycorp, Inc.
Questa, New Mexico

STIFF-8A

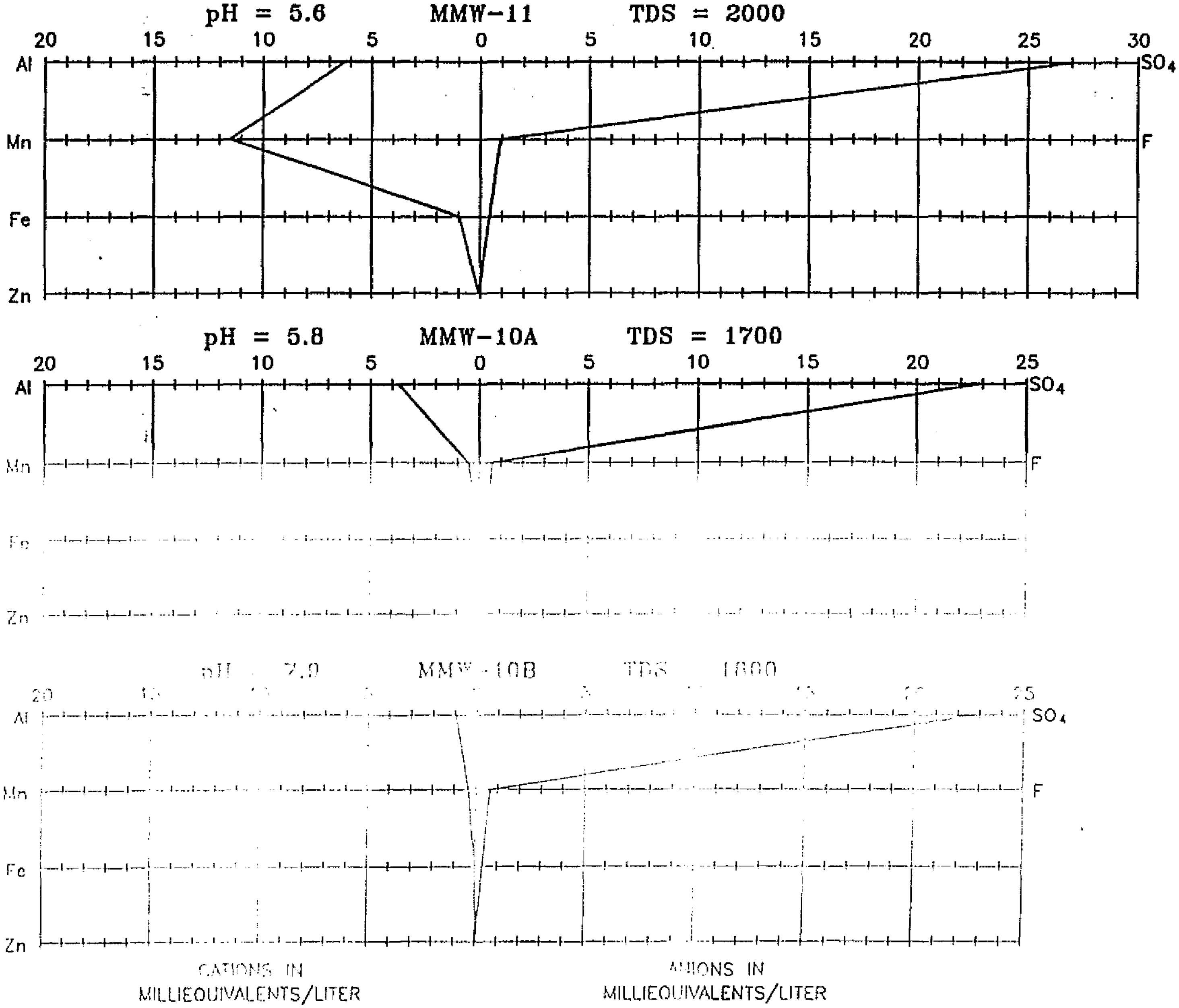


FIGURE: D 5a

SOUTH PASS RESOURCES, Inc.

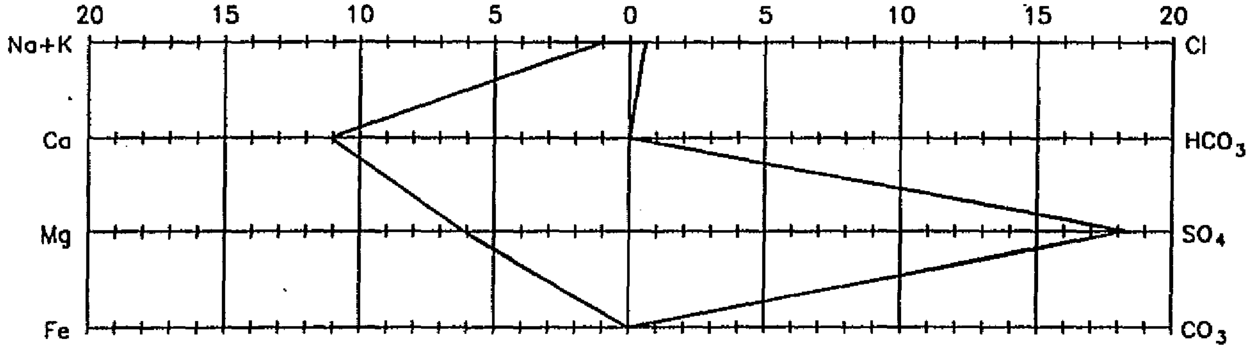
PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS – SUGAR SHACK SOUTH AREA

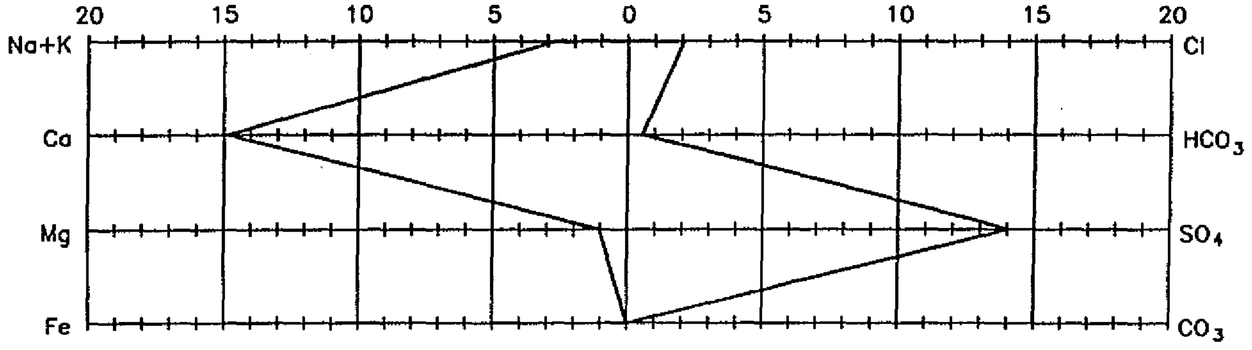
Mine Area – Molycorp, Inc.
Questa, New Mexico

STIFF-9

pH = 4.7 MMW-10C TDS = 1400



pH = 5.0 PORTAL SPRINGS TDS = 2017
(SPRI 5/94, #20)



CATIONS IN
MILLIEQUIVALENTS/LITER

ANIONS IN
MILLIEQUIVALENTS/LITER

FIGURE: D 5b

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS - SUGAR SHACK SOUTH AREA
Mine Area - Molycorp, Inc.
Questa, New Mexico

STIFF-9A

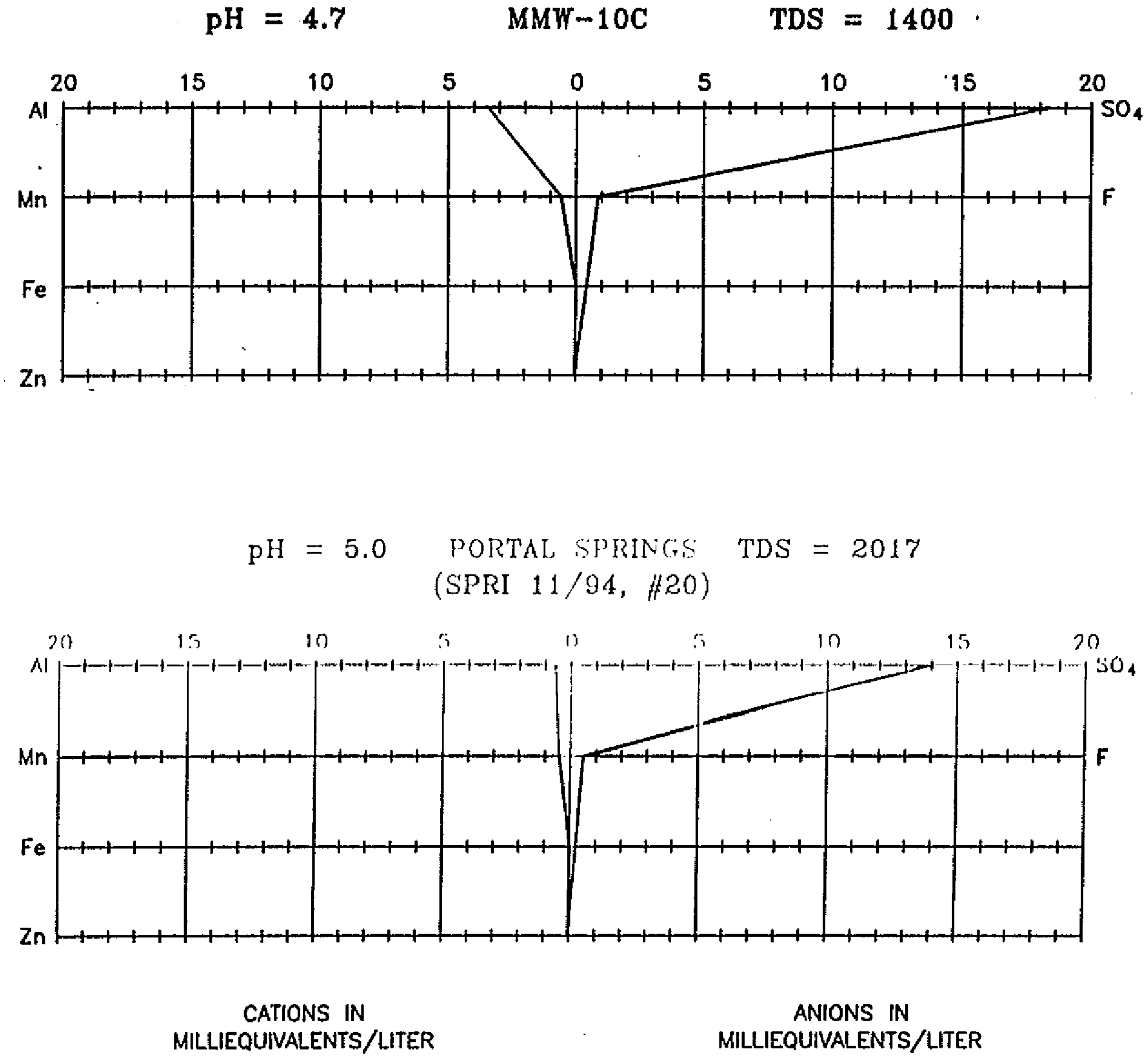
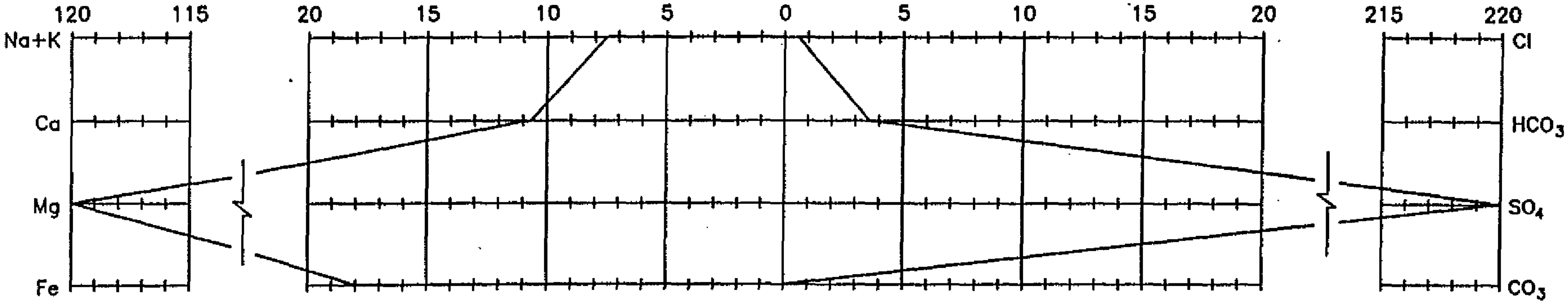


FIGURE:	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS – SUGAR SHACK SOUTH AREA
D 5C	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	Mine Area – Molycorp, Inc. Questa, New Mexico

STIFF-2

pH = 4.4 MMW-7 TDS = 16,000



pH = 7.0 MMW-8A TDS = 2200

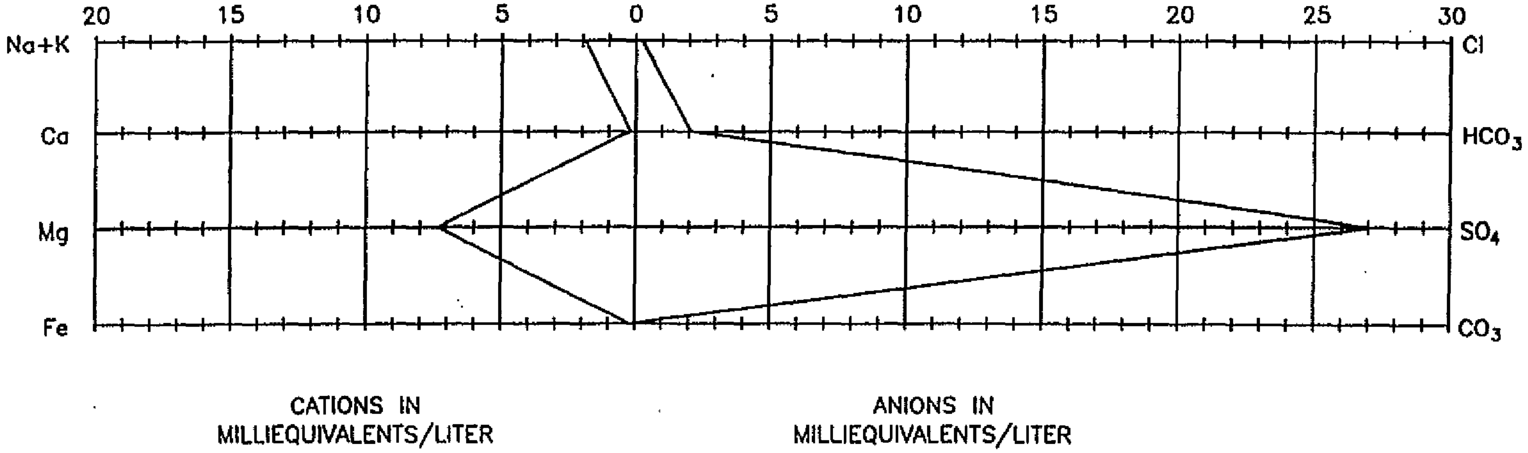
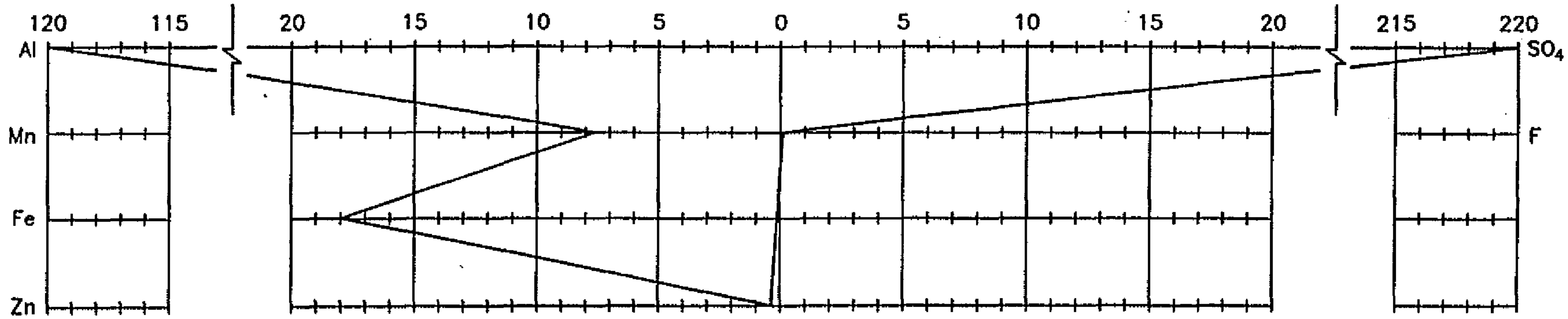


FIGURE: D6	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS – SUGAR SHACK WEST AREA Mine Area – Molycorp, Inc. Questa, New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

STIFF-2A

pH = 4.4 MMW-7 TDS = 16,000



pH = 7.0 MMW-8A TDS = 2200

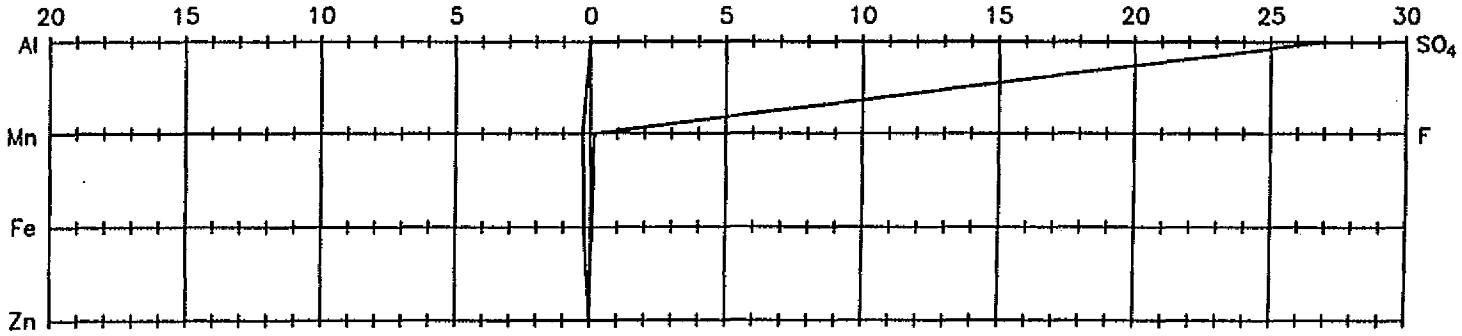


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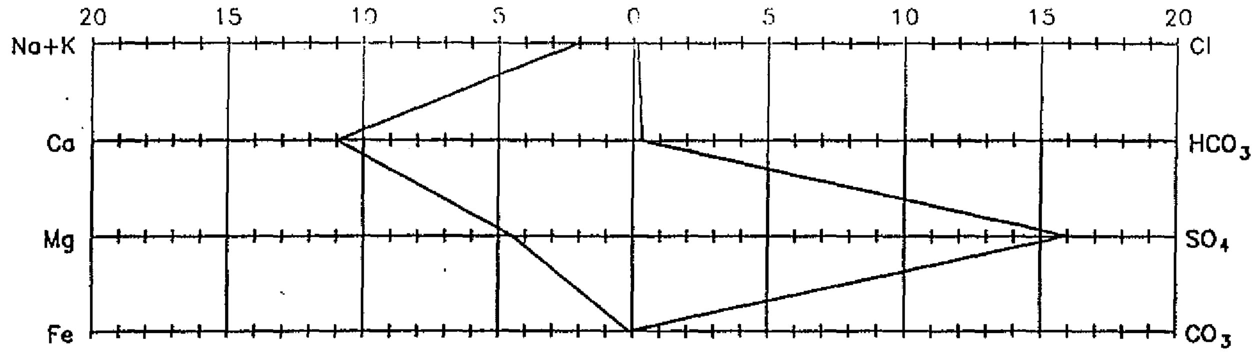
FIGURE: D 6a	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS – SUGAR SHACK WEST AREA Mine Area – Molycorp, Inc. Questa, New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

pH = 6.4 MMW-8B TDS = 1100



pH = 5.1 CABIN SPRINGS TDS = 2040
(Vail, #10)

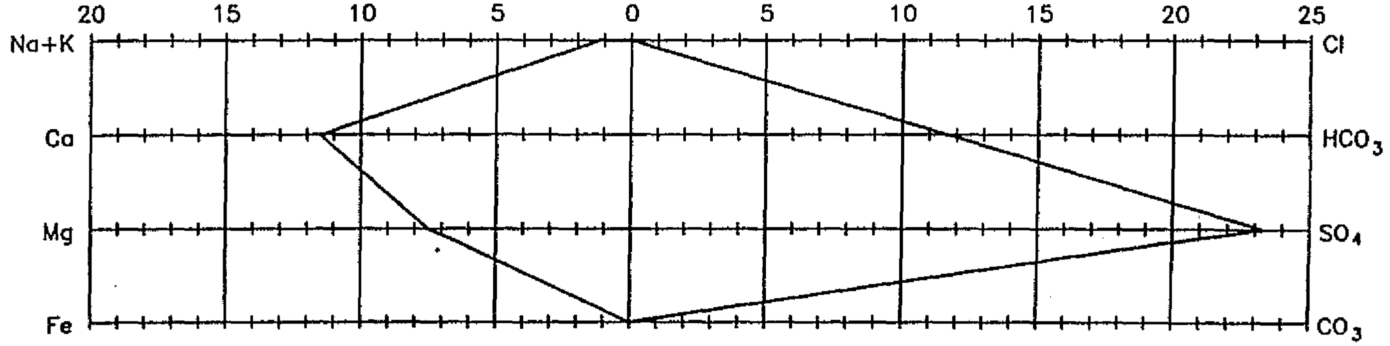


FIGURE: **D 6b**

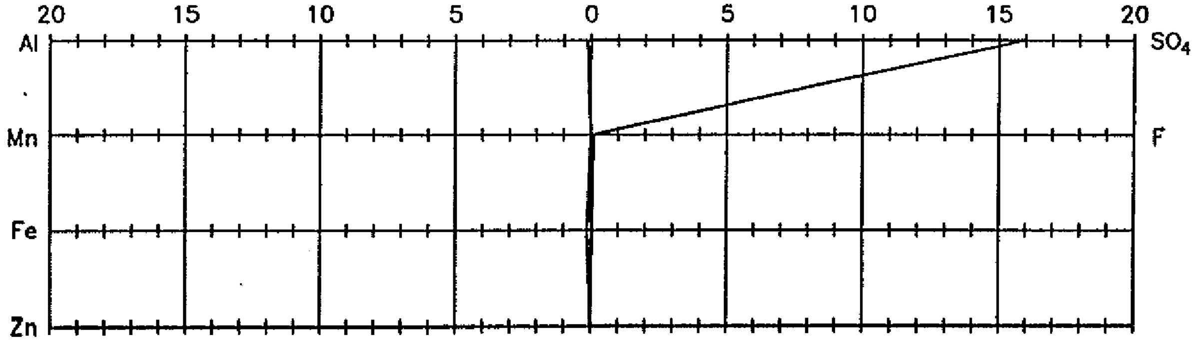
SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS – SUGAR SHACK WEST AREA

Mine Area – Molycorp, Inc.
Questa, New Mexico

pH = 6.4 MMW-8B TDS = 1100



pH = 5.1 CABIN SPRINGS (Vail, #10) TDS = 2040

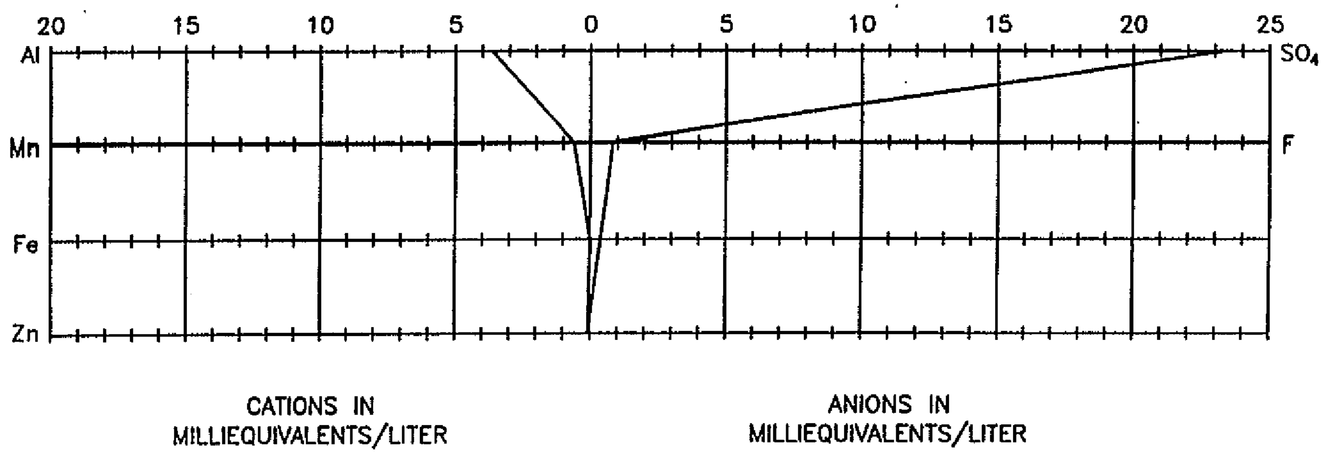


FIGURE: D 6C

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS – SUGAR SHACK WEST AREA

Mine Area – Molycorp, Inc.
Questa, New Mexico

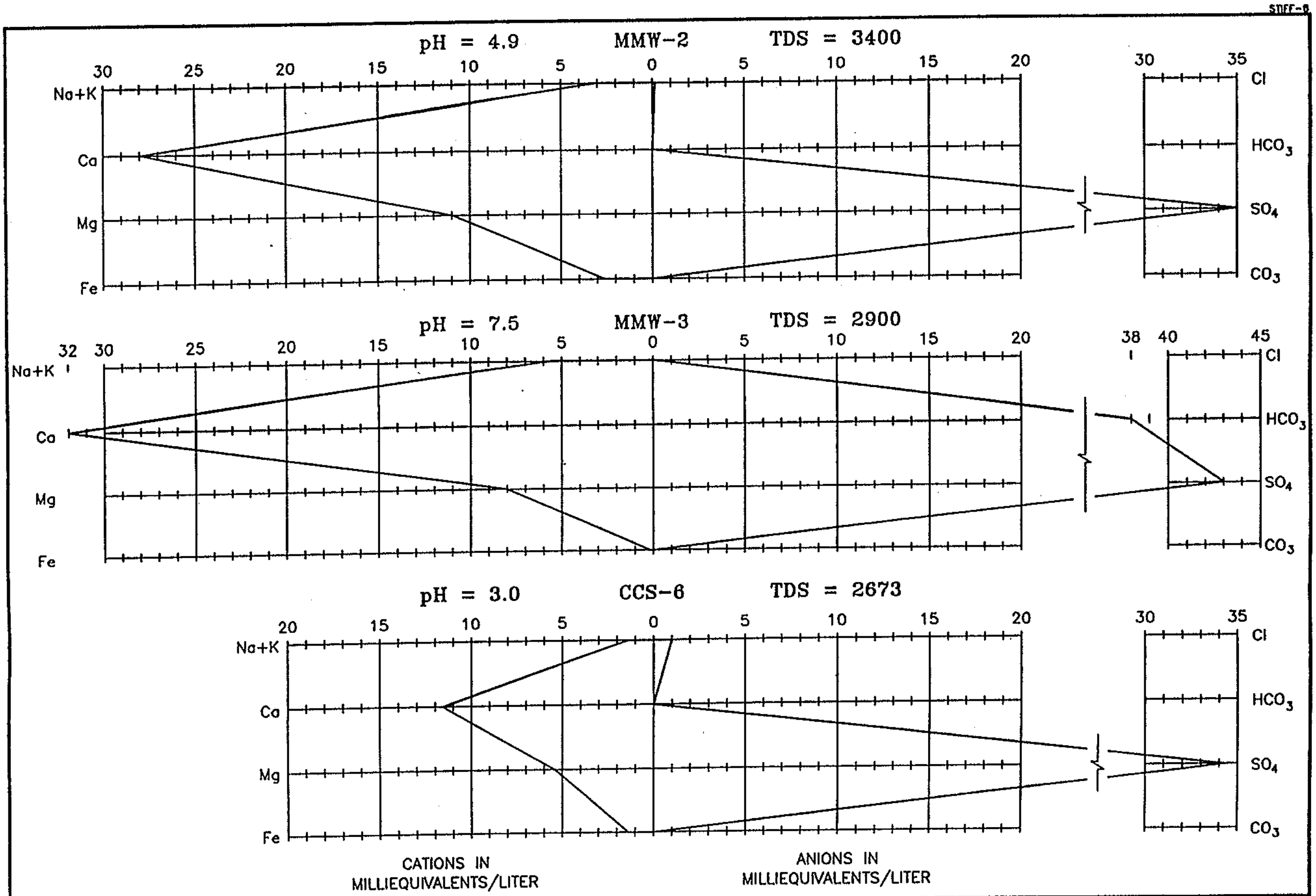


FIGURE: **D7**

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAM – CAPULIN CANYON AREA

Mine Area – Molycorp, Inc.
Questa, New Mexico

STIFF-6A

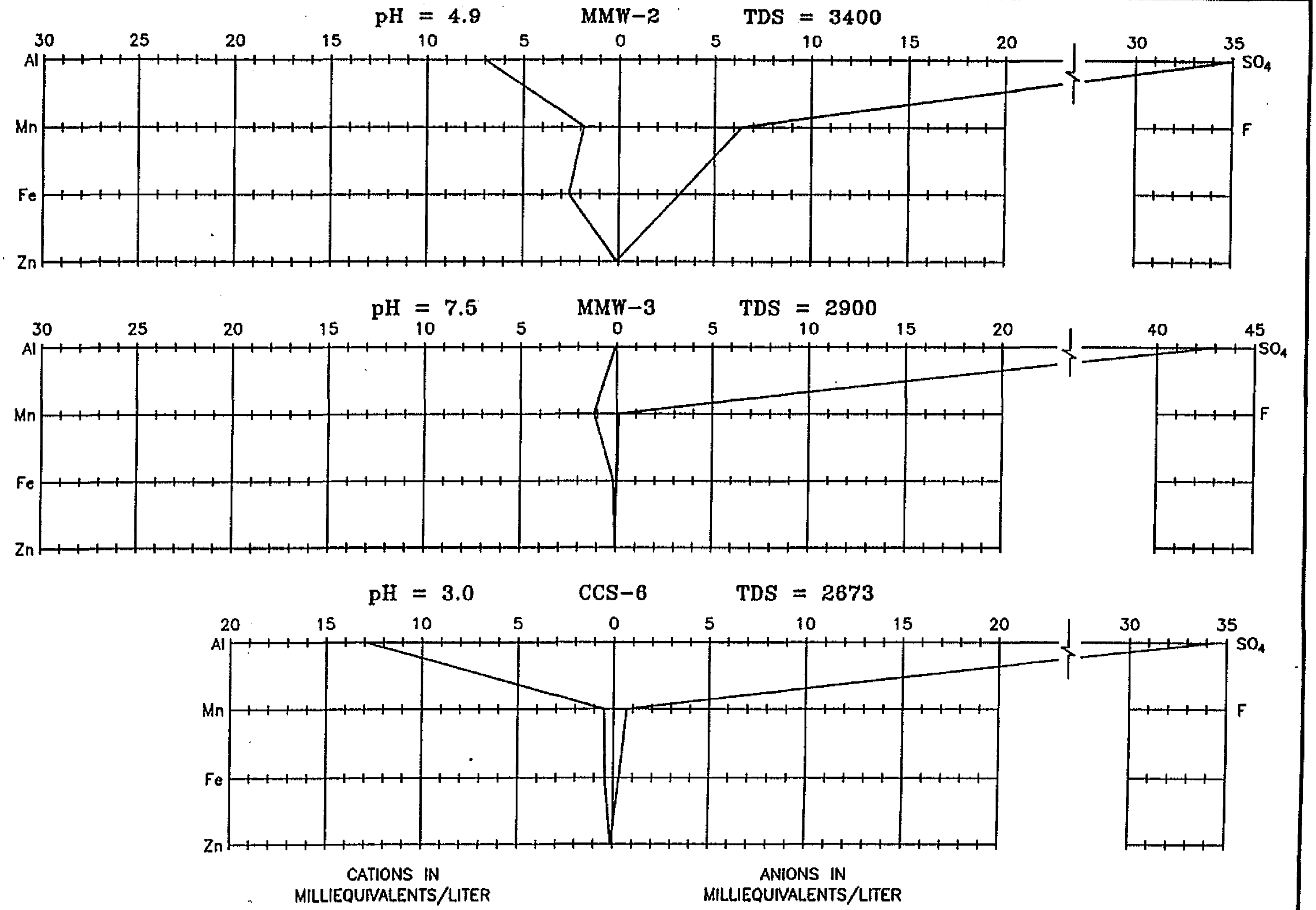
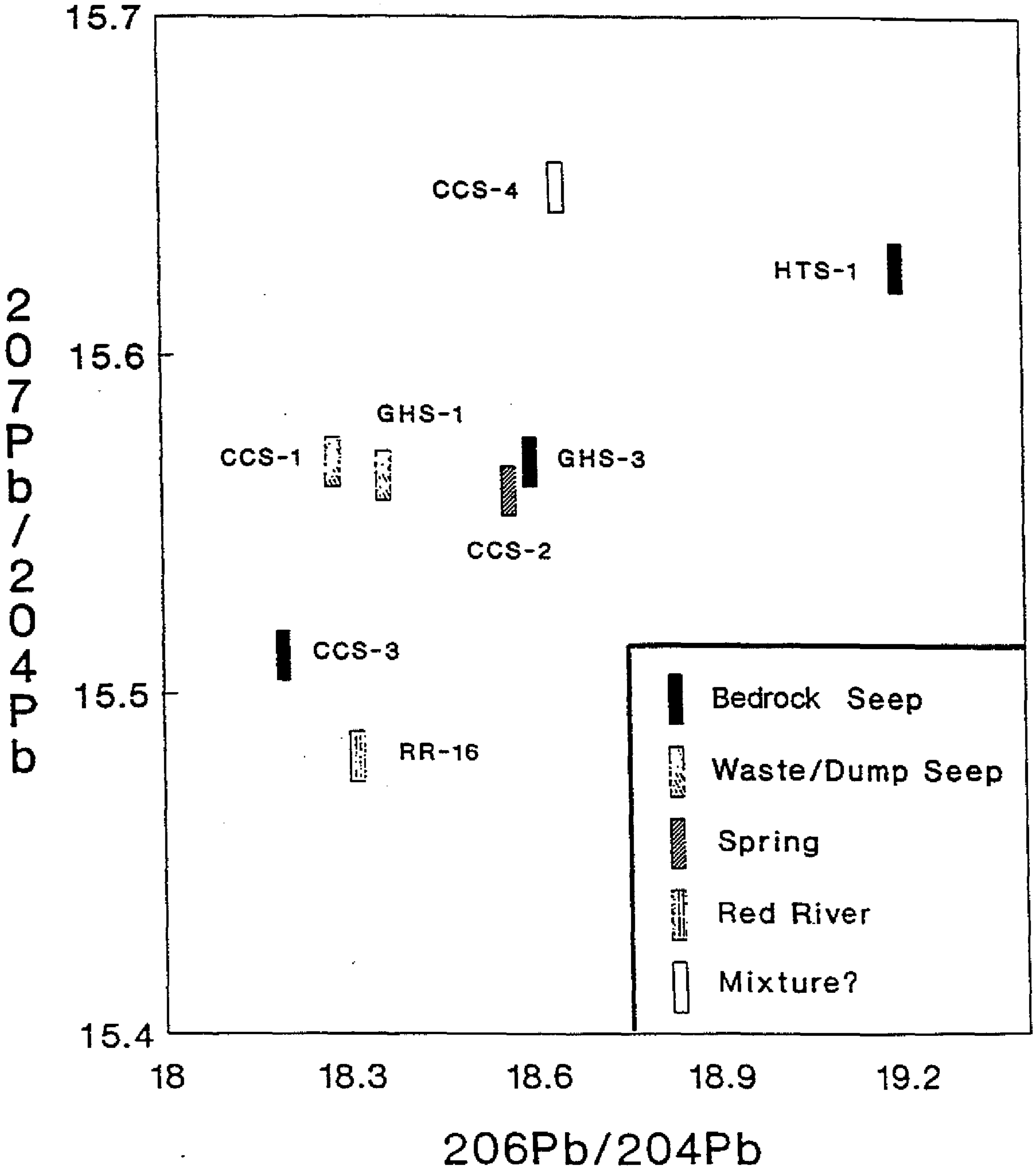


FIGURE:	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAM – CAPULIN CANYON AREA
D 7a	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	Mine Area – Molycorp, Inc. Questa, New Mexico

ISOTOPES

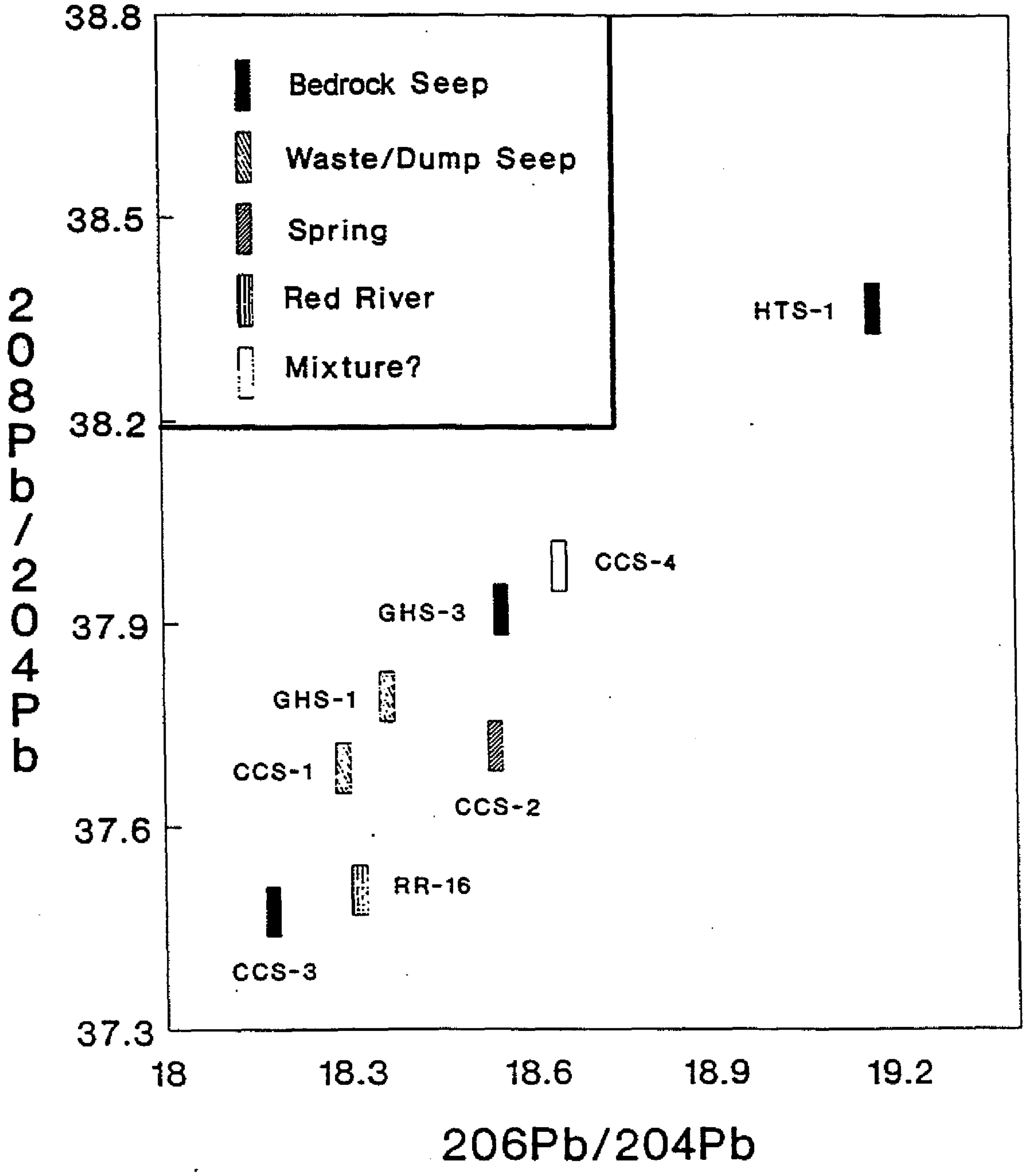
UNOCAL MOLYCORP QUESTA MINE GROUNDWATER STUDY



The waste/dump seep waters (CCS-1, GHS-1) form a cluster that is statistically different from other waters. Data points are shown with true analytical errors.

SOUTH PASS RESOURCES, Inc.				207Pb/204Pb vs 206Pb/204Pb Tailings Area – Molycorp, Inc. Questa, New Mexico	FIGURE: D8
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.		

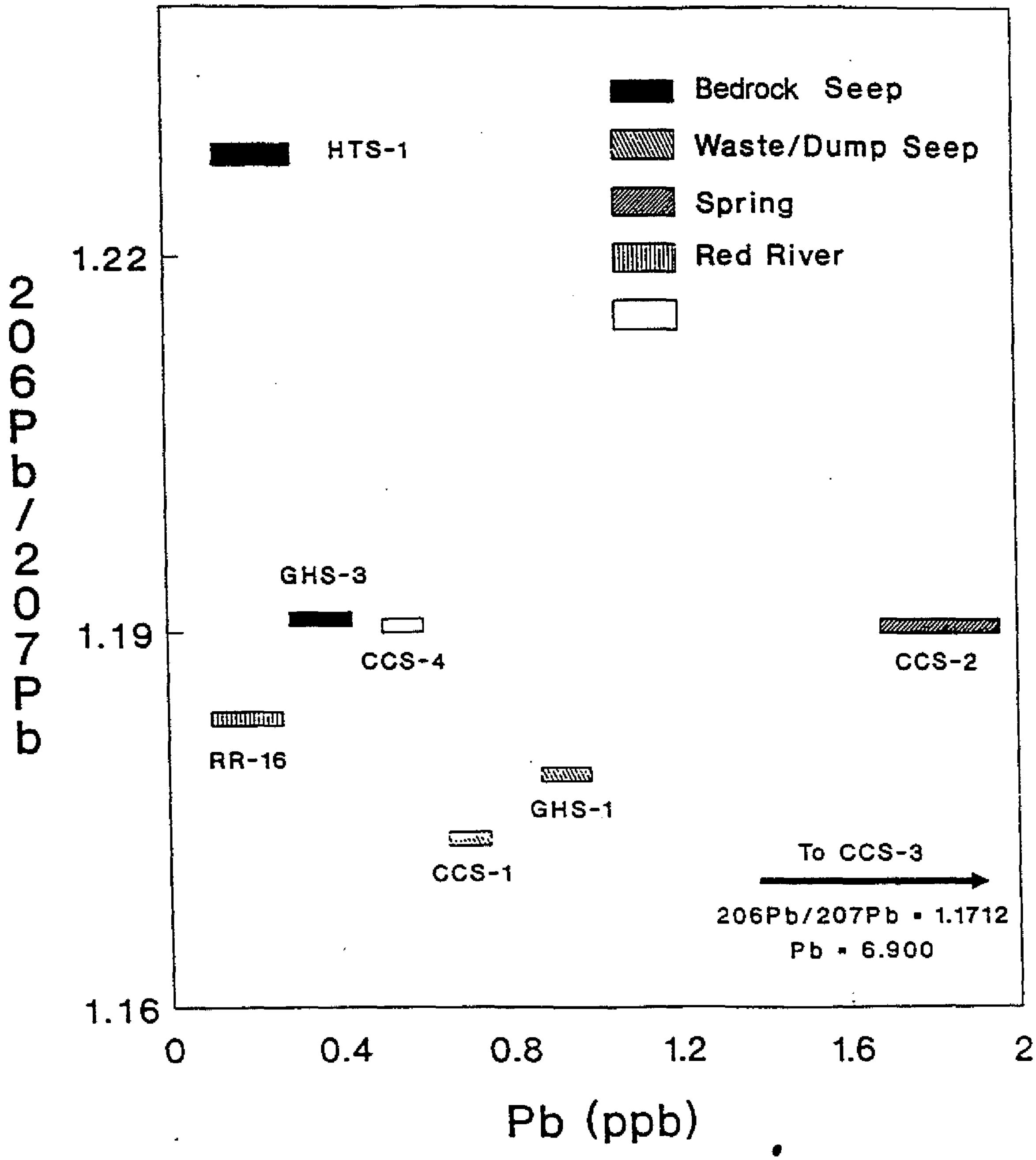
UNOCAL MOLYCORP QUESTA
MINE GROUNDWATER STUDY



The two waste/dump seep waters (CCS-1, GHS-1) may either be a distinct cluster or part of a trend. Data points are shown with true analytical errors.

SOUTH PASS RESOURCES, Inc.				208Pb/204Pb vs 206Pb/204Pb Tailings Area – Molycorp, Inc. Questa, New Mexico	FIGURE:
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.		**D9**

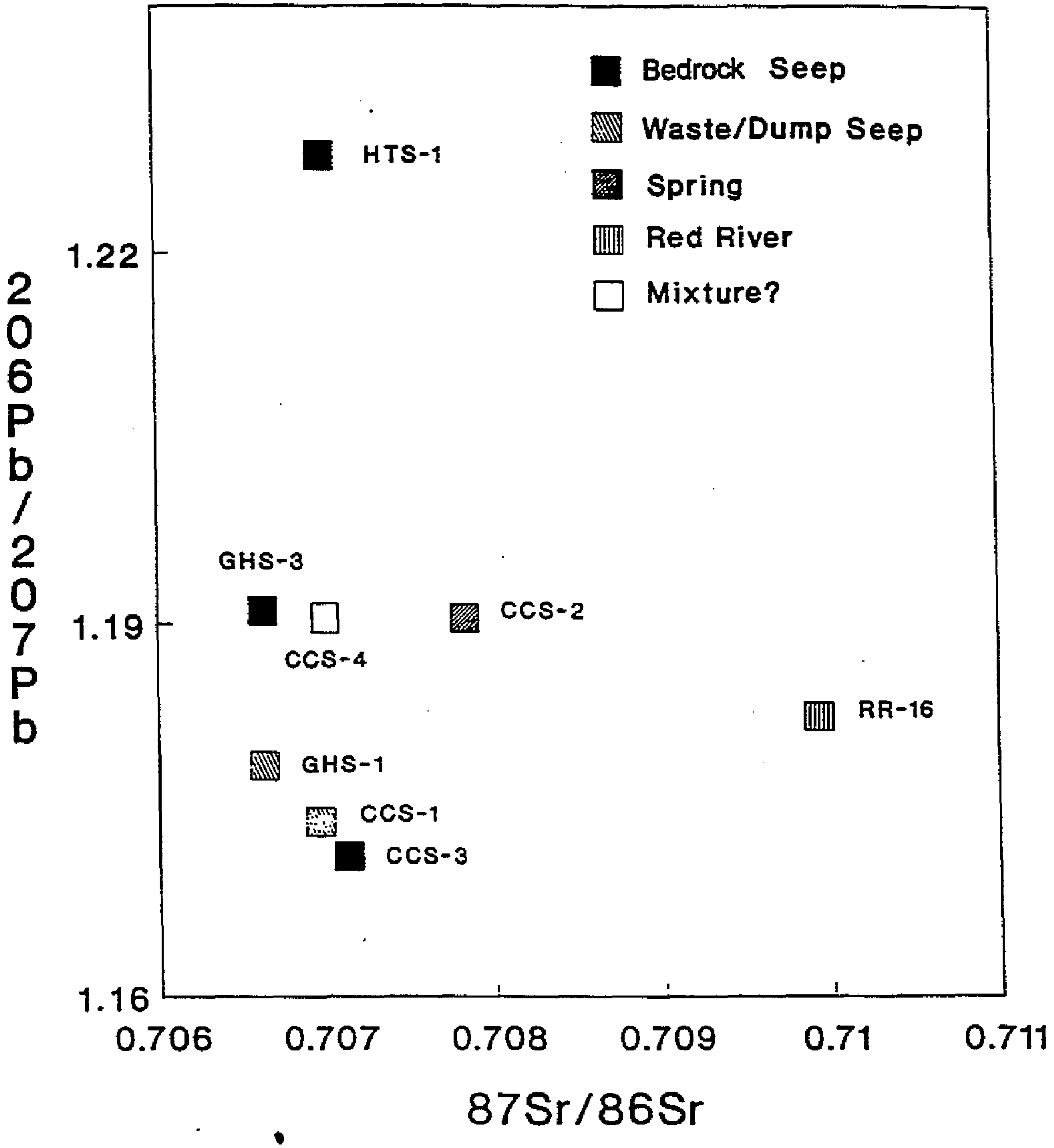
UNOCAL MOLYCORP QUESTA MINE GROUNDWATER STUDY



Waste/dump seep waters (CCS-1, GHS-1) are distinct from other water samples. Long-term water-rock equilibria may explain the clustering of 206Pb/207Pb ratios near 1.19. The error in 206Pb/207Pb is exaggerated 4X for clarity.

SOUTH PASS RESOURCES, Inc.				206Pb/207Pb vs Pb Concentration Tailings Area – Molycorp, Inc. Questa, New Mexico	FIGURE: D10
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.		

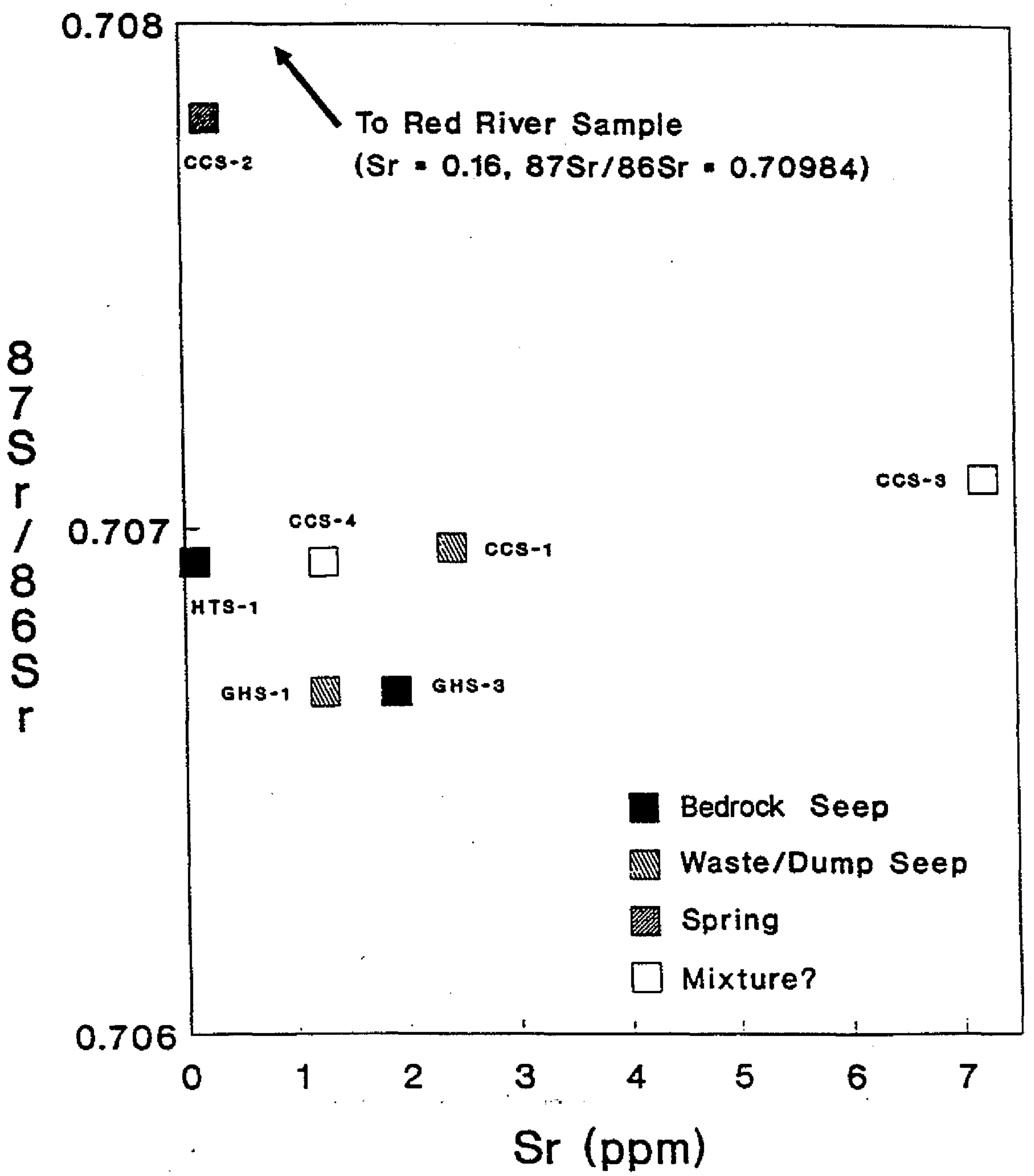
UNOCAL MOLYCORP QUESTA
MINE GROUNDWATER STUDY



The 87Sr/86Sr ratios of natural and waste/dump seep waters cluster. Waste/dump seep waters and CCS-3 cluster; this may be the result of short-term water-waste reactions. Analytical errors are exaggerated 10X to 20X for clarity.

SOUTH PASS RESOURCES, Inc.				206pB/207Pb vs 87Sr/86Sr Tailings Area – Molycorp, Inc. Questa, New Mexico	FIGURE: D11
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.		

UNOCAL MOLYCORP QUESTA MINE GROUNDWATER STUDY



Strontium isotopic/concentration data indicate similar hydrologic systems for natural and waste/dump seep waters. Goathill Gulch may be a distinct hydrologic system. Analytical errors are exaggerated 3X to 4X for clarity.

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

87Sr/86Sr vs Sr Concentration
Tailings Area – Molycorp, Inc.
Questa, New Mexico

FIGURE:
D12

TABLE D1
1994 MONITOR WELL WATER QUALITY DATA FOR MINE AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 1 of 3)

MONITOR WELL	SAMPLE DATE 1994	WELL TD (feet)	Corrected DEPTH TO WATER (feet)	DEPTH TO PUMP INTAKE (feet)	pH (1)	CONDUC-TIVITY(1) (umhos)	TEMP.(1) (°C)	CARBO-NATE (mg/L)	BICARBO-NATE (mg/L)	HYDR-OXIDE (mg/L)	TOTAL ALK (mg/L)	CHLORIDE (mg/L)	FLUORIDE (mg/L)	SULFATE (mg/L)
MMW-2	8-Nov	68	31.69	50	4.90	3,680	7.9	<1	<1	<1	<1	6.8	24.0	2,100
MMW-3	7-Nov	140	27.76	80	7.50	3,970	10.9	<1	222	<1	222	5.8	2.59	1,700
MMW-7	7-Nov	161	61.11	120	4.40	9,490	17.2	<1	<1	<1	<1	21	1.12	10,400
DUP-11A (2)	7-Nov	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	21	0.98	10,500
MMW-8A	8-Nov	178	96.77	140	7.00	2,860	8.4	<1	165	<1	165	8.7	2.72	1,300
MMW-8B	8-Nov	129	96.03	112	6.40	1,780	7.1	<1	19	<1	19	5.6	1.83	730
MMW-10A	8-Nov	144	21.70	100	5.80	2,400	7.8	<1	<1	<1	<1	27	11.2	1,100
DUP-12B (3)	8-Nov	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	26	7.96	1,100
MMW-10A (4)	19-Nov	NA	NA	NA	NA	NA	NA	<1	<1	<1	<1	26	8.28	1,200
MMW-10B	7-Nov	189	21.57	140	7.90	2,250	10.1	10	<1	66	76	28	12.2	1,100
MMW-10C	8-Nov	50	21.80	40	4.70	2,000	11.8	<1	<1	<1	<1	20	15.4	880
MMW-11	7-Nov	184	86.71	150	5.60	2,450	15.7	<1	<1	<1	<1	22	17.6	1,300
MMW-13	8-Nov	145	105.98	130	7.90	2,280	8.9	<1	200	<1	200	14	1.67	770

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.

(2) - Dup 11A = DUPLICATE SAMPLE FOR MMW-7

(3) - Dup 12B = DUPLICATE SAMPLE FOR MMW-10A

(4) - SAMPLED AFTER AQUIFER TEST

NA - Not Available

SOURCE: SAMPLES TAKEN BY SPRI, ANALYTICAL RESULTS FROM MOLYCORP.

TABLE D1
1994 MONITOR WELL WATER QUALITY DATA FOR MINE AREA

MOLYCORP, INC. - QUESTA, NEW MEXICO

(Page 2 of 3)

MONITOR WELL	TDS (mg/L)	SILVER (mg/L)	ALUMINUM (mg/L)	ARSENIC (mg/L)	BARIUM (mg/L)	BERYLLIUM (mg/L)	CALCIUM (mg/L)	CADMIUM (mg/L)	COBALT (mg/L)	CHROMIUM (mg/L)	COPPER (mg/L)	IRON (mg/L)	MERCURY (mg/L)
MMW-2	3,400	<0.10	63.5	<0.005	<0.010	0.015	501	0.024	0.280	<0.010	0.088	50.8	<0.0002
MMW-3	2,900	<0.10	0.75	<0.005	0.047	<0.004	567	0.0024	0.089	<0.010	<0.010	0.076	<0.0002
MMW-7	16,000	<0.50	943	<0.05	0.108	0.104	544	0.096	4.91	0.193	4.84	384	<0.0002
DUP-11A (2)	16,000	<0.50	961	<0.05	0.074	0.122	534	0.092	4.99	0.17	5.04	375	<0.0002
MMW-8A	2,200	<0.10	<0.05	<0.005	0.103	<0.004	466	0.002	<0.010	<0.010	<0.010	2.84	<0.0002
MMW-8B	1,100	<0.10	0.44	<0.005	0.016	<0.004	206	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MMW-10A	1,700	<0.10	33.4	<0.005	<0.010	0.008	275	0.028	0.148	<0.010	0.558	<0.050	<0.0002
DUP-12B (3)	1,700	<0.10	34.2	<0.005	<0.010	0.008	270	0.024	0.137	<0.010	0.58	<0.050	<0.0002
MMW-10A (4)	1,700	<0.010	31.6	<0.005	<0.010	0.006	245	0.0224	0.141	<0.010	0.534	0.086	<0.0002
MMW-10B	1,800	<0.10	8.74	<0.005	0.034	0.007	347	0.025	0.074	<0.010	0.179	0.101	<0.0002
MMW-10C	1,400	<0.10	31.1	<0.005	0.014	0.007	204	0.026	0.106	<0.010	0.38	<0.050	<0.0002
MMW-11	2,000	<0.10	56.3	<0.005	0.016	0.013	276	0.036	0.266	0.036	0.919	0.129	<0.0002
MMW-13	1,400	<0.10	<0.05	<0.005	0.036	<0.004	316	<0.0005	0.013	<0.010	<0.010	0.198	<0.0002

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.

(2) - Dup 11A = DUPLICATE SAMPLE FOR MMW-7

(3) - Dup 12B = DUPLICATE SAMPLE FOR MMW-10A

(4) - SAMPLED AFTER PUMP TEST

SOURCE: SAMPLES TAKEN BY SPRI, ANALYTICAL RESULTS FROM MOLYCORP.

TABLE D1
1994 MONITOR WELL WATER QUALITY DATA FOR MINE AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 3 of 3)

MONITOR WELL	POTASSIUM (mg/L)	MAGNESIUM (mg/L)	MANGANESE (mg/L)	MOLYBDENUM (mg/L)	SODIUM (mg/L)	NICKEL (mg/L)	LEAD (mg/L)	ANTIMONY (mg/L)	SELENIUM (mg/L)	SILICON (mg/L)	THALLIUM (mg/L)	VANADIUM (mg/L)	ZINC (mg/L)
MMW-2	10.8	137	52.1	<0.02	64.6	0.61	<0.002	<0.05	<0.05	20.3	<0.005	<0.010	9.48
MMW-3	7.5	96.2	34.5	<0.02	103	0.236	<0.002	<0.05	<0.005	7.6	<0.005	<0.010	1.36
MMW-7	12.0	1250	72.1	<0.10	175	10.5	0.10	<0.25	<0.025	22.7	<0.005	0.104	11.7
DUP-11A (2)	12.1	1230	73.3	<0.10	178	10.7	0.06	<0.25	<0.025	22.6	<0.005	0.106	11.9
MMW-8A	3.8	85.6	7.15	<0.02	41.5	<0.020	<0.002	<0.05	<0.005	11.1	<0.005	<0.010	<0.050
MMW-8B	2.9	55.5	0.202	<0.02	33.9	0.059	<0.002	<0.05	<0.005	17.3	<0.005	<0.010	0.211
MMW-10A	2.8	77.9	13.8	<0.02	26.5	0.325	<0.002	<0.05	<0.005	14.3	<0.005	<0.010	2.29
DUP-12B (3)	2.5	76.7	12.8	<0.02	26.4	0.293	<0.002	<0.05	<0.005	14.0	<0.005	<0.010	2.07
MMW-10A (4)	3.7	69.7	13.1	<0.02	25.6	0.279	0.004	<0.05	<0.005	14.1	<0.005	<0.010	2.68
MMW-10B	3.5	80.3	8.55	<0.02	25.8	0.201	0.021	<0.05	<0.05	12.8	<0.005	<0.010	1.5
MMW-10C	2.8	75.2	16.3	<0.02	20.2	0.0347	<0.002	<0.05	<0.005	9.9	<0.005	<0.010	3.2
MMW-11	3.4	133	31.7	<0.02	25.5	0.593	0.086	<0.05	<0.005	14.2	<0.005	<0.010	5.0
MMW-13	5.4	38.7	1.02	0.05	30	<0.020	<0.002	<0.05	<0.005	8.8	<0.005	<0.010	0.222

NOTES:

(1) Ph, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.

(2) - Dup 11A = DUPLICATE SAMPLE FOR MMW-7

(3) - Dup 12B = DUPLICATE SAMPLE FOR MMW-10A

(4) - SAMPLED AFTER PUMP TEST

SOURCE: SAMPLES TAKEN BY SPRI, ANALYTICAL RESULTS FROM MOLYCORP.

TABLE D2
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 1 of 4)

Sample ID	Sample Description	pH Meter	pH Strip	Temp (F°)	Conductivity (uhmos)	Total Alkalinity (mg/L)	TDS (mg/L)	TSS (mg/L)	Aluminum Susp. (mg/L)	Aluminum Dis. (mg/L)	Fluoride (mg/L)	Iron (mg/L)
BC-1	BC 75' N of High St. bridge	6.40	5.0	44.9	49.8	20	82	26	0.75	0.60	0.15	2.70
BC-2	BC 500' S of Spring flow from BCS-1	6.55	5.5	43.6	66.2	18	78	10	<.5	0.60	0.12	1.00
BCS-1	Spring, 1.2 mi. N High St.	4.42	5.0	44.7	478.0	0	530	<1	<.5	5.20	0.30	<.01
BOS-1	Spring, W side of Bobita Campground		6.0	61.0	605.0	44	737	8	<.5	<.5	0.32	0.16
CCS-1	Middle sump Capulin Canyon		3.0	50.9	13,440	0	24,950	8	1.00	1,310	53.30	258.30
CCS-2	Spring drainage W side Capulin Canyon		7.0	56.9	260.0	54	416	107	2.80	2.2	0.62	11.72
CCS-3	Adit W side Capulin Canyon		4.0	45.1	2,960	0	2,686	295	1.60	53.6	12.00	25.20
CCS-4	Seep, Capulin Canyon S of adit		4.0	48.2	1,775	0	1,193	12.7	<.5	23.2	5.70	2.35
CCS-5	Culvert drain W side of Capulin Canyon		4.0	66.7	1,700	0	1,896	3.7	<.5	74.8	9.80	0.21
CCS-6	Seep, 200' E Capulin Canyon		3.0	73.7	2,430	0	2,673	6.4	<.5	116.2	13.00	7.68
CLB-1	Columbine Creek-200' up from confluence		6.5	57.7	134.0	49	70	3	<.5	<.5	0.18	0.34
ECCS-1	Seep near river, E of Capulin Canyon		6.5	60.5	580.0	26	413	8	<.5	<.5	1.50	0.32
ECCS-2	Seep S of Hwy 38, E of Capulin Canyon		4.0	62.0	1,752	0	913	1	<.5	73	5.20	0.79
EGHS-1	Seep, S of Hwy 38, E of Goathill		7.0	55.6	810.0	47	843	1.2	<.5	<.5	0.47	0.15
GHS-1	Seepage Goat Hill dump		2.0	69.1	11,140	0	23,890	39	0.97	1,183	36.70	257.00
GHS-2	Seep from bore hole +GHS1		2.0	73.0	11,350	0	17,623	29	1.70	1,125	43.30	252.00
GHS-3	Natural seep from volcanic rock					0	11,980	94	1.30	645	26.00	250.00
HCS-1	seeps, Upper Hanson Creek Canyon		2.5	44.2	5,520	0	6,493	13.6	<.5	185.4	15.00	177.90
HCS-2	seep, downgradient from HCS-1		2.5	50.6	5,390	0	6,230	7.6	<.5	154	15.60	164.80
HCS-3	Seep S of Hwy 38, W Hanson Creek		4.0	77.0	1,232	0	1,773	<1	<.5	2.6	1.40	0.43
HTS-1	Upper Hot-N-Tot Canyon	2.86	2.3	48.2	2,670	0	2,610	43	<.5	97.8	2.30	212.80
MC-1	Mallette Creek-Alpine Lodge	6.86	6.0	52.2	80.4	22	96	16	0.65	0.60	0.25	1.20
PC-1	Pioneer Creek, Arrowhead Lodge	7.34	7.0	45.1	107.0	43	94	15	<.5	0.50	0.10	0.70
POS-1	seep, Portal Springs W of mine portal		4.5	54.4	1,900	10	1,800	34	<.5	21.3	153.00	8.24
RR-1	RR W of confluence w/BltCrk	7.40	6.0	43.8	99.3	43	82	4	<.5	0.50	0.86	1.10
RR-2	RR 50' E of BC Confluence	7.58	6.5	45.9	108.0	70	88	18	<.5	0.50	0.08	0.80
RR-3	RR behind Alpine Lodge	7.53	6.0	48.2	93.7	51	92	22	0.5	0.50	0.10	2.10
RR-4	RR, Goose Lake Rd/East RR	7.73	7.0	43.5	130.0	47	98	13	<.5	<.5	0.10	0.70
RR-5	RR, Hot-N-Tot Creek/upstream	7.45	7.0	47.0	144.0	59	100	32	0.75	0.50	0.11	2.20

TABLE D2
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 2 of 4)

Sample ID	Sample Description	pH Meter	pH Strip	Temp (F°)	Conductivity (uhmos)	Total Alkalinity (mg/L)	TDS (mg/L)	TSS (mg/L)	Aluminum Susp. (mg/L)	Aluminum Dis. (mg/L)	Fluoride (mg/L)	Iron (mg/L)
RR-6	RR, Hot-N-Tot Creek/dwnstream	7.52	6.5	48.0	145.0	43	92	34	0.60	<.5	0.11	1.90
RR-7	RR down from Sulpher Gulch	7.48	7.0	62.0	122.0	48	108	49	0.75	<.5	0.16	2.10
RR-8	RR upstream from mill gate	7.53	6.5	57.0	129.0	56	106	57	0.50	0.60	0.12	2.14
RR-9	RR, 200' up from Hanson Creek confluence	7.46	7.0	54.5	144.0	53	104	31.2	<.5	<.5	0.13	1.70
RR-10	RR, downstream of Portal Springs	7.46	7.0	54.5	196.0	48	112	61.2	1.60	<.5	0.20	2.41
RR-11	RR, Down from Hanson Creek confluence	7.51	6.5	51.5	177.0	61	104	17.6	<.5	<.5	0.11	1.29
RR-12	RR 100' E of Columbine Creek Confluence		6.5	55.5	196.0	48	213	58	0.54	0.6	0.30	2.35
RR-13	RR, highway bridge W of Columbine Creek		6.5	55.5	196.0	50	163	54	0.54	<.5	0.20	1.80
RR-14	RR up from Goathill Gulch		6.5	58.1	241.0	42	123	52	0.72	<.5	0.32	2.05
RR-15	RR down from Goathill Gulch		7.0	57.0	224.0	52	130	62	0.83	<.5	0.32	2.24
RR-16	RR Questa Ranger Station		6.5	54.0	171.0	41	150	106	0.83	<.5	0.35	2.72
SGS-1	Sulpher Gulch-spring pond	6.65	7.0	75.5	753.0	83	620	6.5	<.5	<.5	1.30	0.75
SSC-1	seep, S of west end Sugar Shack South		5.0	55.0	2,350	33	2,017	214	2.20	5.3	92.00	<.01

NOTES:

Sampling by SPRI; analytical results from Molycorp, Inc.

(1) - pH Strip, Temperature and Conductivity were measured field measurements.

All samples are total metals except Alum. Suspended and Alum. Dissolved

< symbols are detection limits.

TABLE D2
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 3 of 4)

Sample ID	Ferrous Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Copper (mg/L)	Molybdenum (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Silica (mg/L)	Chlorine (mg/L)	Cadmium (mg/L)	Sulfate (mg/L)
BC-1		0.003	0.041	0.025	0.03	<.02	2.5	<1.0	6	1.6	20	2.5	<.005	12
BC-2		0.002	0.034	0.025	0.02	<.02	2.7	<1.0	12.5	3.5	22	3	<.005	13.7
BCS-1		<.002	1.360	0.491	0.18	<.02	9.4	1.5	48.9	27.2	46	5	0.005	171
BOS-1		<.002	<.01	0.060	0.01	<.02	13.1	1.2	85.2	21.5	20	20	<.005	217
CCS-1	7.0	<.002	416.20	146.00	15.3	<.02	23.7	<1.0	504	1,032	92.4	30	0.75	11,996
CCS-2		0.036	0.213	0.149	0.024	<.02	9.5	2.6	20.2	4.2	46.6	7.5	<.005	56.8
CCS-3	<1.0	0.078	12.600	6.960	0.162	<.02	70.3	9.6	348	84	76	14.5	0.021	1,736
CCS-4		<.002	10.300	2.620	0.21	<.02	30.9	2	145	38.5	52	9.5	0.007	541.7
CCS-5		0.004	28.900	7.600	1.21	<.02	19.1	1.7	118	76.9	112	9.5	0.036	1,152
CCS-6		0.003	13.600	4.470	0.998	<.02	30	3.5	233	65	62	35	0.017	1,649
CLB-1		<.002	<.01	0.022	0.008	<.02	1.5	<1.0	17	1.8	14	2.5	<.005	1.7
ECCS-1		<.002	<.01	0.115	0.01	<.02	9.8	1.2	52.8	12.7	28	18.5	<.005	128.3
ECCS-2		0.003	8.740	2.820	0.921	<.02	55.7	3.5	138	41	28	95	0.015	669
EGHS-1		<.002	<.01	0.042	0.009	<.02	9.5	1.7	104.4	23.1	18	10.5	<.005	190
GHS-1	8.0	<.010	239.50	82.70	8.6	<.02	11.7	<1.0	444	760	104	37	0.381	13,312
GHS-2	10.0	<.010	263.80	86.40	8.5	<.02	18.4	<1.0	432	704	96.7	40	0.409	11,667
GHS-3	1.0	0.017	22.00	4.22	1.58	<.02	32.6	<1.0	504	405	102	15	<.005	7,763
HCS-1	2.0	0.004	20.300	3.740	0.512	<.02	17.8	<1.0	504	274	63.5	10	0.012	3,876
HCS-2		<.002	17.100	3.880	0.629	<.02	17.2	<1.0	454	199	75.9	16	0.013	3,436
HCS-3		0.004	0.445	0.183	0.025	<.02	48	2.6	156	18	22	90	<.005	377
HTS-1	7.0	0.009	6.250	2.960	1.14	<.02	2.1	<1.0	55.9	43.5	100	16	0.012	848
MC-1		<.002	0.054	0.043	0.02	<.02	3.9	1.4	8.2	3.1	32	4.5	<.005	16.4
PC-1		<.002	0.036	0.014	0.02	<.02	2	<1.0	19.8	2.4	15	5	<.005	20
POS-1		<.002	6.830	2.490	0.05	<.02	26.2	3.4	206	16.6	32	27	0.01	622
RR-1		<.002	0.033	0.048	0.02	<.02	2.2	<1.0	15	2.5	14	4	<.005	7
RR-2		<.002	0.039	0.012	0.01	<.02	2	<1.0	17.7	2.4	14	2.5	<.005	3
RR-3		0.004	0.086	0.018	0.02	0.03	2.3	<1.0	15.7	2.5	17	4	<.005	13.8
RR-4		<.002	0.030	0.006	0.01	<.02	1.9	<1.0	17	2.2	12	5	<.005	2.2
RR-5		0.003	0.065	0.022	0.02	<.02	2.3	<1.0	17	2.5	14	5	<.005	17.4

TABLE D2
WATER QUALITY DATA FOR THE RED RIVER - (SPRI, MAY 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 4 of 4)

Sample ID	Ferrous Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Copper (mg/L)	Molybdenum (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Silica (mg/L)	Chlorine (mg/L)	Cadmium (mg/L)	Sulfate (mg/L)
RR-6		0.003	0.080	0.034	0.02	<.02	2.3	<1.0	16.6	2.4	14	5	<.005	17.7
RR-7		0.004	0.080	0.030	0.02	<.02	2.8	<1.0	20	3.1	16	5	<.005	15.9
RR-8		0.004	0.082	0.027	0.02	<.02	2.8	<1.0	19.1	3	24	4.5	<.005	19.5
RR-9		0.003	0.064	0.202	0.01	<.02	2.6	<1.0	18.6	3.4	14	5	<.005	14.5
RR-10		0.004	0.109	0.018	0.02	<.02	2.9	<1.0	20.4	3.9	17	5	<.005	17.4
RR-11		0.004	0.048	<.005	0.02	<.02	2.6	<1.0	18.5	3.3	20	4	<.005	11.4
RR-12		0.004	0.126	0.042	0.018	<.02	3	<1.0	21.4	4.6	64	2.5	<.005	33.6
RR-13		0.004	0.078	0.031	0.016	<.02	2.9	<1.0	21	4.4	18	3	<.005	23.5
RR-14		0.006	0.242	0.067	0.02	<.02	3	1	23	5	18	3	0.007	29.7
RR-15		0.004	0.213	0.062	0.018	<.02	3	<1.0	22.8	4.9	20	3.5	<.005	34.7
RR-16		0.014	0.290	0.073	0.024	<.02	2.7	<1.0	22.1	4.5	14	6.5	<.005	28.9
SGS-1		<.002	0.252	0.099	0.01	0.19	17.6	4	119	17.7	24	22.5	<.005	160
SSC-1		0.026	12.300	2.920	0.213	0.88	58.7	5.3	298	13.5	30	72.5	0.02	679.8

TABLE D3
WATER QUALITY FOR THE RED RIVER (VAIL ENG., OCTOBER 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 1 of 2)

ID No.	Sample Description	pH*	Conductivity (mg/L)	Aluminum Susp. (mg/L)	Aluminum Dis. (mg/L)	Sulfate (mg/L)	TDS (mg/L)	TSS (mg/L)	Calcium Carbonate (mg/L)
1	Above Red River	7.8	204	<.5	<.5	16	152	3.3	78
2	Bitter Creek	8	261	<.5	<.5	86	204	8.7	52
3	Below Red River	7.8	243	<.5	<.5	44	176	4.0	88
4	June Bug	8	257	<.5	0.5	59	192	5.3	88
5	Elephant Rock Campground	8	264	<.5	0.5	65	204	6.0	75
6	Below Hansen Creek @ split in creek	7.4	271	<.5	0.5	68	212	5.3	68
6A	Hansen Creek	4.1	2,580	1.0	131.0	2,116	3,057	7.3	0
6B	Hwy curve to left (going west)	7.2	291	0.75	<.5	97	224	7.3	76
7	Above Mill	7.6	296	0.75	0.5	93	228	8.7	70
8	Below Sulfur Gulch	7.9	305	0.075	0.5	97	245	7.3	74
8A	Above Portal	7.8	303	0.65	<.5	110	228	7.3	64
9	Columbine Creek	8.2	159	<.5	0.5	7	132	1.3	74
9A	Red River at W. side Fgrqst Motel	8.1	297	0.65	0.5	100	228	6.7	65
10	Above Columbine Creek	7.9	323	0.88	<.5	108	228	6.0	67
10A	Company Cabins	8	340	1.0	<.5	129	244	8.0	65
10B	Cabin Springs	5.1	1,874	<.5	32.7	1,118	2,040	14.7	0
11	Below Columbine Creek	7.4	341	1.4	<.5	143	245	7.3	56
11A	Thunder Bridge	7.7	355	1.4	<.5	143	245	8.0	53
11B	Above Thunder Bridge	7.7	344	1.4	<.5	143	238	7.3	64
12	Goat Hill Campground	7.8	377	1.2	<.5	163	260	7.3	58
13	Above Capulin	7.8	378	1.4	<.5	170	260	6.7	58
14	Below Capulin	7.9	384	1.8	<.5	162	258	6.0	58
14A	Small Canyon to North of Highway	7.8	384	1.8	<.5	166	265	6.0	57
15	Eagle Rock Campground	7.9	389	2.5	0.5	185	265	8.7	51
16	Ranger Station p.m.	7.8	400	2.9	<.5	197	268	9.3	44
16	Ranger Station a.m.	-	-	2.9	<.5	196	278	8.0	49
17	Below Ranger Station @SW end ER Lake	7.8	405	3.1	<.5	204	284	12.7	45
18	Red River Sewage Trt Plant well 11-08-94	3.85	1,419	<.5	36.0	788	1,472	-	0

* Field Measurements by Vail Engeering.

TABLE D3
WATER QUALITY FOR THE RED RIVER (VAIL ENG., OCTOBER 1994)
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 2 of 2)

ID No.	Sample Description	Fluoride (mg/L)	Total Cadmium (mg/L)	Total Lead (mg/L)	Total Iron (mg/L)	Total Manganese (mg/L)	Total Zinc (mg/L)	Total Copper (mg/L)	Total Molybdenum (mg/L)
1	Above Red River	0.1	<.01	<.1	<.05	0.088	0.012	<.01	<.1
2	Bitter Creek	0.4	<.01	<.1	0.61	0.143	0.005	<.01	<.1
3	Below Red River	0.3	<.01	<.1	0.05	0.198	0.034	0.01	<.1
4	June Bug	0.4	<.01	<.1	0.162	0.066	0.039	0.01	<.1
5	Elephant Rock Campground	0.4	<.01	<.1	0.162	0.077	0.034	<.01	<.1
6	Below Hansen Creek @ split in creek	0.5	<.01	<.1	0.234	0.055	0.035	<.01	<.1
6A	Hansen Creek	1.75	0.025	0.114	36.0	10.7	3.4	0.128	<.1
6B	Hwy curve to left (going west)	0.5	<.01	<.1	0.27	0.121	0.044	<.01	<.1
7	Above Mill	0.6	<.01	<.1	0.342	0.143	0.051	<.01	<.1
8	Below Sulfur Gulch	0.6	<.01	<.1	0.306	0.132	0.044	<.01	<.1
8A	Above Portal	0.7	<.01	<.1	0.288	0.143	0.041	<.01	<.1
9	Columbine Creek	0.2	<.01	<.1	<.05	<.01	<.005	<.01	<.1
9A	Red River at W. side Fgrqst Motel	0.7	<.01	<.1	0.252	0.198	0.058	<.01	<.1
10	Above Columbine Creek	0.7	<.01	<.1	0.342	0.242	0.071	<.01	<.1
10A	Company Cabins	0.7	<.01	<.1	0.27	0.539	0.117	0.01	<.1
10B	Cabin Springs	14.8	0.03	<.1	<.05	18.1	2.8	0.348	<.1
11	Below Columbine Creek	0.5	<.01	<.1	0.27	0.605	0.129	0.01	<.1
11A	Thunder Bridge	0.8	<.01	<.1	0.216	0.528	0.127	0.01	<.1
11B	Above Thunder Bridge	0.8	<.01	<.1	0.288	0.561	0.124	0.01	<.1
12	Goat Hill Campground	0.9	<.01	<.1	0.198	0.506	0.12	0.01	<.1
13	Above Capulin	1.0	<.01	<.1	0.216	0.506	0.12	0.01	<.1
14	Below Capulin	1.0	<.01	<.1	0.288	0.583	0.136	0.02	<.1
14A	Small Canyon to North of Highway	1.0	<.01	<.1	0.324	0.594	0.14	0.02	<.1
15	Eagle Rock Campground	1.1	<.01	<.1	0.432	0.957	0.239	0.04	<.1
16	Ranger Station p.m.	1.1	<.01	<.1	0.432	0.902	0.228	0.03	<.1
16	Ranger Station a.m.	1.2	<.01	<.1	0.342	0.946	0.23	0.03	<.1
17	Below Ranger Station @SW end ER Lake	1.3	<.01	<.1	0.396	1.01	0.255	0.03	<.1
18	Red River Sewage Trt Plant well 11-08-94	1.6	0.012	<.1	4.6	5.2	1.6	0.06	<.1

* Field Measurements by Vail Engeering.

TABLE D4
WATER QUALITY OF MINE WATER
MOLYCORP, INC. - QUESTA, NEW MEXICO

Sample Location	Shaft No. 1 Shallow	Shaft No. 1 Deep (mg/L)	Shaft No. 1 Top (mg/L)	Shaft No. 1 1000 ft (mg/L)	Shaft No.2 (mg/L)	Decline (mg/L)	Decline (mg/L)	Open Pit (mg/L)
Date	NA	NA	10/94	10/94	NA	NA	10/94	10/94
pH	6.9	7.7	6.96	6.96	7.2	7.5	6.7	3.1
Aluminum	NA	NA	0.5	0.5	<0.5	1.2	1.0	303.0
Sulfate	1,455	1,480	1,665	1,720	1,345	1,004	1,720	11,561
TDS	3,072	3,386	3,276	3,584	3,164	2,468	3,507	24,420
Fluoride	NA	13.1	NA	NA	5.0	7.10	NA	NA
Cadmium	<0.005	0.01	<0.01	<0.01	<0.005	<0.005	<0.01	0.304
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.10	<0.10
Iron	0.30	<0.05	50.0*	46.2*	<0.05	<0.05	39	164.0
Manganese	8.6	15.5	11.5	12.0	5.10	1.20	13.30	408.0
Zinc	1.3	0.30	0.283	1.54	2.70	2.80	1.52	70.1
Copper	<0.01	0.02	0.03	0.03	<0.01	<0.01	0	6.7
Molybdenum	2.70	2.20	2.22	2.22	1.80	1.20	2.44	0.41
Arsenic	<0.01	<0.01	NA	NA	<0.01	<0.01	NA	NA
Mercury	<0.20	<0.20	NA	NA	<0.20	<0.20	NA	NA

* Total Iron

TABLE D5
WATER QUALITY OF PRODUCTION WELLS
MINE AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO

	Red River Sewage Plant Well	Columbine Well No. 2
pH (mg/L)	3.96	5.9
Aluminum (mg/L)	25.2	NA
Sulfate (mg/L)	776	536
TDS (mg/L)	1,034	848
Fluoride (mg/L)	2.13	2.0
Cadmium (mg/L)	<0.005	<0.01
Lead (mg/L)	<0.1	<0.05
Iron (mg/L)	27	<0.05
Manganese (mg/L)	5.0	0.01
Zinc (mg/L)	1.9	0.69
Copper (mg/L)	0.051	<0.01

APPENDIX E

Summary report on latest hydrogeological studies and sampling at Molycorp tailings area, excerpted from SPRI Report, April 13, 1995.

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MAY 24 1995

ROUND WATER BUR

DISCUSSION OF GEOLOGY, HYDROGEOLOGY, AND WATER QUALITY OF THE TAILINGS AREA
Molycorp Facility
Taos County, New Mexico

prepared for
Molycorp, Inc.
Questa Division
P.O. Box 469
Questa, NM 87556

prepared by
South Pass Resources, Inc./SPRI

April 13, 1995

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ROUND WATER BUR

REMEDIATION PLAN for the TAILINGS AREA
Molycorp Facility
Taos County, New Mexico

prepared for
Molycorp, Inc.
Questa Division
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Questa, NM 87556

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April 13, 1995

SOUTH PASS RESOURCES, Inc.
SPRI

TAILINGS AREA

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1.0 INTRODUCTION

The Molycorp molybdenum mine is located on the western slope of the Taos Range of the Sangre de Cristo Mountains, Taos County in north-central New Mexico (Figure 1). State Highway 38 runs along the north side of the Red River and connects the mine area with the Town of Red River (6 miles to the east) and the Town of Questa (6 miles to the west). For the purposes of this report, the area that consists of tailings embankments, tailings ponds, seepage controls, and outfall facilities is referred to as the ***Tailings Area***. The Tailings Area is located about 1 mile west of the town of Questa and 0.5 mile north of the Red River (Figure 2). The significant features associated with the area are shown on Figure 3.

In 1989, Molycorp retained the services of South Pass Resources, Inc. (SPRI) to evaluate impacts of past and present Molycorp mining operations on ground-water and surface-water quality. SPRI's most recent (Fall 1994) activities have involved the design, installation, and testing of five (5) new monitor/extraction wells in the Tailings Area. This report presents the findings of the Fall 1994 investigation and of previous investigations. The geologic, hydrogeologic and water-quality aspects of the Molycorp mining activities in the study area (Section 2.0 of this report) form the basis for the proposed Remediation Plan presented in Section 3.0.

SUMMARY OF SPRI FALL 1994 INVESTIGATION

Between August 28 and September 27, 1994, SPRI overviewed the installation and testing of one monitor and four extraction wells in the Tailings Area. The purpose of this field effort was to:

- further delineate ground-water flow patterns between the tailings ponds and the Red River;
- further identify the geologic controls on ground-water flow;
- further characterize perched-water conditions in the Tailings Area;
- continue the investigation of contaminant flow paths from the tailings ponds; and
- emplace extraction wells for potential remediation efforts.

The wells that were installed during the Fall 1994 field effort, and the details of their installation and testing, are summarized below. The locations of these wells are shown on Figure 3. [All of the wells (except MMW-12 which has 4-inch PVC casing) were constructed with 8-inch PVC casing and screen to allow for pumping and extraction, if desired.]

Tailings Area Monitor/Exploration Wells
Installed in August/September 1994

Well No.	Total Depth (feet)	Screened Interval (feet)	Well Completed In
EW-1	157	83 - 157	basalt/basalt gravel
EW-2	214	104 - 114 120 - 132 151 - 185	sandy gravel sandy gravel, gravelly sand, clay basalt gravel in clay
EW-3	104	62 - 77	sandy clay/clayey gravel
EW-4	58	42 - 58	clayey gravel
MW-12	234	203 - 234	basalt and basalt gravel

These new monitor and exploration wells in the Tailings Area supplement monitor wells previously installed under SPRI direction (see SPRI, 1993; 1994). These wells are summarized below:

Tailings Area Monitor Wells
Previously Installed by SPRI
(1993)

Well No.	Total Depth (feet)
MW-11	249
MW-7A, -7B, -7C	146
MW-9A, -9B	147
MW-8	225
MW-10A	136

A partial listing of other monitor and extraction wells in the Tailings Area that pre-date SPRI field activities are summarized below. (Note: A complete list of all wells located in the study area is unknown at this time.)

Other Wells Located in the Tailings Area
(Partial Listing)

Well No.	Total Depth (feet)	Year Installed
Change House (CH)	250	1967
MW-1	117	1979
MW-2	80	1979
MW-3	52	1979
MW-4	102	1979
MW-A	38	NA
MW-B	18	NA
MW-C	15	NA
MW-6	101	NA

Figure 3 shows the locations of all SPRI and other wells installed in the Tailings Area.

2.0 GEOLOGY, HYDROGEOLOGY, AND WATER QUALITY OF THE TAILINGS AREA

The ground-water flow patterns -- and the contaminant flow paths -- within the Tailings Area are controlled by the site geology. The geologic and hydrogeologic factors involved are summarized below. The current water quality issues of the Tailings Area are also presented. A more detailed discussion of the geology, hydrogeology, and water quality of the Tailings Area is presented in SPRI's report, *Discussion of Geology, Hydrogeology, and Water Quality of the Tailings Area, Molycorp Facility, Taos County, New Mexico*, dated March 31, 1995 (see Appendix A for Table of Contents).

OVERVIEW OF GEOLOGY AND HYDROGEOLOGY OF THE TAILINGS AREA

1. Five new wells were emplaced in 1994, which added to an existing system composed of nine monitor wells, the Change House production well, and MW-6 (east of Dam No. 1). A limited amount of data is available for private wells south of the Molycorp property. The description of the hydrogeologic character of the area has been based on data from all of these wells.

2. The major hydrogeologic units in the Tailings Area are the Santa Fe Group and the underlying volcanic sequence. The Santa Fe Group consists of:

   - An Upper Aquifer Unit (UAU) composed of brown sandy gravels and gravelly sands with some pale red brown silty, sandy clay;
   - a Middle Aquitard Unit (MAU) composed of pale red brown clay and gravelly clay;
   - a Lower Aquifer Unit (LAU) composed of sandy or clayey gravel, with some thin, cemented sand units; and
   - a Basal Aquitard Unit (BAU) composed of bouldery clay.

   In addition to the above units, a thin sequence of volcanic silty sands, and gravelly clayey sands recognized in the Dam No. 4 area are probably part of the Santa Fe Group, but their stratigraphic position is not clear.

   The volcanic aquifer consists of a basalt unit that extends beneath both tailings ponds and a sequence of ash flow tuffs and lava flows in fault-contact with the basalt and the Santa Fe Group along the west side of Dam No. 4.

3. Structural relationships in the Tailings Area are dominated by northeast-trending high-angle fault lines, probably resulting from a combination of mid-Tertiary rifting, erosion, and sedimentation. These structural zones influence the ground-water flow paths.

4. The key ground-water relationships are:

   - Multiple perched zones in the Santa Fe Group with a main perched zone south of Dam No. 1 involving the lower UAU and upper MAU.

   - The main perched zone may extend to the Red River (based on logging and slug test data in monitor wells south of Dam No. 1 and on private well and field springs data farther south). It may also merge with the deeper LAU aquifer; however, upward hydraulic gradients in the LAU prevent leachate from impacting deeper zones.

   - From the fault zone along the west side of Dam No. 1 westward, the piezometric surface may be a composite which includes heads related to semi-confined conditions for the basalt gravel unit (MW-1 and EW-1) and unconfined conditions elsewhere (MW-11). The upper part of the basalt unit beneath Dam No. 4 may be unsaturated.

   - East of the fault zone, saturated conditions may be continuous from the lower LAU and the BAU across the basalt unit.

5. The leachate-contaminated shallow private wells appear to be screened in the main perched zone while deeper wells in the LAU and in basalt unit contain water that meets drinking-water quality standards.

6. Ground-water flow directions in the basalt aquifer, based on three-point calculations and potentiometric maps, range between S20°W and S75°W. Hydraulic gradients vary from 0.1 ft/ft to as low as 0.003 ft/ft. Steeper gradients result from localized discharge conditions such as occur along permeable fracture zones (such as in the MW-11 area). Estimates for a flow rate based on a mixing equation calculation for the volcanic aquifer at Dam No. 4 resulted in a value of 5.9 cubic feet per second (cfs) and a high degree of dilution for any leachate that might reach the water table. Analyses of water samples from MW-11, the Red River, and springs along the north side of the Red River down-gradient from Dam No. 4 support the results of the mixing equation.

7. Aquifer tests conducted at EW-2, -3, and -4 in 1994 gave the following results:

    - EW-3 (sand and gravel unit at base of UAU): hydraulic conductivity of 87 gallons per day per square foot (gpd/ft^2). The aquifer test (pump rate of 7 to 8 gallons per minute) created drawdown at the up-gradient well MW-7A located 210 feet north of EW-3. An aquifer test conducted at MW-11 in 1993 resulted in a hydraulic conductivity ranging between 6,833 and 14,102 gpd/ft^2 for the basalt.

    - EW-2 (basalt gravel within BAU): hydraulic conductivity of 913 gpd/ft^2.

    - EW-4: broke suction before one well volume was discharged.

OVERVIEW OF WATER QUALITY OF THE TAILINGS AREA

8. Results of water-quality analyses from sampling of the monitor-well system in August 1993 and November 1994 are augmented by smaller data sets from the pre-1993 monitor-well samples. A limited amount of water-quality data is also available from the private wells.

9. STIFF Diagrams indicate that the water in the main perched zone (and shallower perched zones) is a calcium sulfate water. The Change House well water (sodium and potassium bicarbonate water) and the sample from the BAU at MW-12 (calcium bicarbonate) may be more representative of regional water quality (Winograd, 1959).

10. The basalt aquifer typically contains a bicarbonate water with either calcium or sodium plus potassium as the dominant cation phase. Locally, at MW-1 and EW-1, the ground water is classified as a calcium sulfate water (STIFF Diagram). Leakage of leachate from the main perched zone westward across the fault zone on the west side of Dam No. 1 is the probable source of the sulfate.

11. Total dissolved solids (TDS) and sulfate are the chief chemical parameters and exceed State standards in the main perched zone and, locally, in the basalt aquifer (MW-1 and EW-1).

12. Comparison of 1993 and 1994 water-quality data for wells in the main perched zone shows decreases in sulfate at MW-2, -3, and -4 and an increase at MW-7A. Water samples from the two new wells in the main perched zone showed lower concentrations for sulfate and calcium. The LAU well MW-7C shows an increase in sulfate while MW-10 shows a decrease.

13. Causes for these changes in sulfate concentrations result from a combination of factors including:

- Precipitation of gypsum after the sample was collected and before analysis (EW-3 and EW-4).
- Dilution from natural recharge combined with no new slurry additions to the Dam No. 1 ponds.
- Slugs of older higher concentration leachate reaching a down-gradient well.
- Shallow southeastward flow from beneath the Dam No. 4 pond area reaching MW-7A.
- Changes in natural recharge rates.
- Older (pre-1994) main perched zone wells are screened in sandy gravels of the lower UAU and clays of the upper MAU while the 1994 wells are in the sandy gravel above the clays only. Screens may intercept ground water following different flow paths (i.e. through different lithologies) that may have different chemical histories (e.g., dissolution and precipitation cycles for gypsum associated with clay-rich zones).
- Bacterial activity in wells with steel casing (MW-1, -2, -3, and -4) which can influence iron concentrations.
- Analytical errors.

14. The basalt aquifer at EW-1 and MW-1 shows an increase in sulfate which may result from the down-gradient position of these wells with respect to the main perched zone. At MW-11, south of Dam No. 4, there was a decrease in sulfate concentrations.

15. Mixing equations indicate that the Red River dilutes sulfate and TDS concentrations in inflow from the perched zones, including the main perched zone, to well below State standards.

- A vadose zone (partly alluvial, partly basalt) of approximately 190-foot thickness beneath the pond would attenuate the sulfate concentration entering the ground water.

- The sulfate concentration for the pond water below Dam No. 4 may be less than the combined 002/003 Outfall water at the Red River used in the calculations.

Monitoring of water quality at MW-11 and along the Red River indicates that the rate of ground-water flow in the basalt aquifer causes significant dilution of any pond leachate that may migrate through the thick vadose zone to the water table.

3.4 IMPACT ON THE RED RIVER

Data from two U.S. Geological Survey stream gauges have been used to evaluate the impacts of tailings water on the Red River: one at the Ranger Station (1.5 miles east of Questa), and the other at the confluence of the Red River with the Rio Grande River (a distance of 8.1 miles). The section of the Red River that may be impacted by the tailings ponds is 1.84 miles in length (roughly from the 002/003 Outfall west to the area of the Fish Hatchery). Water levels for wells near the river are close to, but above, river level which indicates that the Red River is a gaining stream for the segment opposite Dam No. 1.

Accretions from tributary sources to segments of the Red River between the gauges have been studied by Wilson and Associates (1978), Water Resources Associates (1984), Dames and Moore (1987), and Vail (1993). These different studies generally conclude that the net gain between Questa and the confluence is roughly 30 cfs. Vail (1993) provides the most recent and detailed estimates for tributary source discharges and their sulfate concentrations to the Red River. Water-quality data from sampling along the Red River are provided on Table 3, and sampling locations (and corresponding sulfate concentrations) are shown on Figure 6. Accretion estimates for the area from the Big Springs Complex (which includes Questa Springs) eastward to the highway bridge over the Red River (the alluvial segment) are given below.

	Flow Rate (Q) (cfs)	Sulfate Concentration (C) (mg/L)
Cold springs from alluvium east of Red River Gorge		
piped to Fish Hatchery	2.7	80
directly to Red River	0.4	80
Field drainage (probably includes seepage from springs east of Big Springs)	2.76	240
002 Outfall (seepage from 001 and 002 barriers)	0.6	840

The estimated rate of flow for the Red River just upstream of the alluvial segment at the highway bridge is 46 cfs and the sulfate concentration is 119 mg/L. Using the values above, the calculation for mixing is:

$$C_m = \frac{\sum_{1}^{n} C_n Q_n}{\sum_{1}^{n} Q_n}$$

$$\frac{(46)(119)+2.7(80)+0.4(80)+2.76(240)+0.6(840)}{46+2.7+0.4+2.76+0.6} = 131.3$$

Based on this calculation, the tributary sulfate input to the Red River directly from the alluvial segment would be diluted to 131.3 mg/L sulfate. A Red River water sample taken 500 feet west of Big Springs Complex has a sulfate concentration of 138 mg/L.

Estimates for tributary sources along the north side of the Red River Gorge (from Big Springs Complex to the Fish Hatchery) are based on estimates of warm spring flow (the assumption, as noted earlier, is that warm water is derived from ground water moving through the volcanic pile).

	Flow Rate (Q) (cfs)	Sulfate Concentration (C) (mg/L)
Warm springs from volcanics directly to the river:		
Warm springs potentially influenced by seepage	1.65	120
Warm springs not influenced by seepage	2.18	20

Adding the inflows from the alluvial segment between the highway bridge and the head of the gorge results in a flow to the upper portion of the gorge on the order of 52 cfs (assuming 138 mg/L sulfate for the Red River below Big Springs). Using the mixing equation and spring flows directly to the river:

$$C_m = \frac{\sum_1^n C_n Q_n}{\sum_1^n Q_n} = \frac{(138)(52)+(120)(1.65)+(2.18)(20)}{52+1.65+2.18} = 132.86$$

The sulfate is diluted to 132.86 mg/L. The two Red River samples measured in this segment of the river have sulfate concentrations of 126 and 129 mg/L.

The sulfate concentrations in water samples collected from springs in the upper Red River Gorge are (see Table 3 and Figure 6):

- 115 mg/L for Sample Location 12;
- 126 mg/L for Sample Location 14; and
- 20 mg/L for Sample Location 15.

The water temperatures for these springs were 15.3°C, 14.5°C, and 16.4°C, respectively. Red River water in the same area has a temperature of 10.3 to 11.2°C. The spring temperatures seem to indicate that the springs' source is ground water that is derived from the volcanic aquifer, not river water recharged to the volcanic aquifer along the fault zone near Pope Lake. If the river is discharging to the volcanic aquifer at the fault zone (as suggested by the MW-11 water level), it is not losing much water to the aquifer and temperature effects are not evident.

An issue raised in the SPRI (1994) report regarding the assumption that MW-11 was down-gradient from the pond (southwesterly flow): why would the well have a substantially lower sulfate concentration than the springs farther down-gradient along the Red River? Two possible answers to this question are:

1) There was an earlier pulse of seepage water that had higher sulfate than presently measured (such that the spring samples represent older water than MW-11).

2) There is some iron-sulfide in the basalt that oxidizes in the vadose zone and releases some sulfate to the ground water. The spring at Sampling Location 14 is located on the south side of the Red River and it has a sulfate concentration of 126 mg/L. Localized iron sulfide mineralization in the fracture volcanics on both sides of the river could be supplying the sulfate.

The spring at Sampling Location 15 has a very low sulfate concentration (20 mg/L). It is possible that the higher sulfate springs are discharging water that lies close to the water table and that the water at Sampling Location 15 comes from a deeper source.

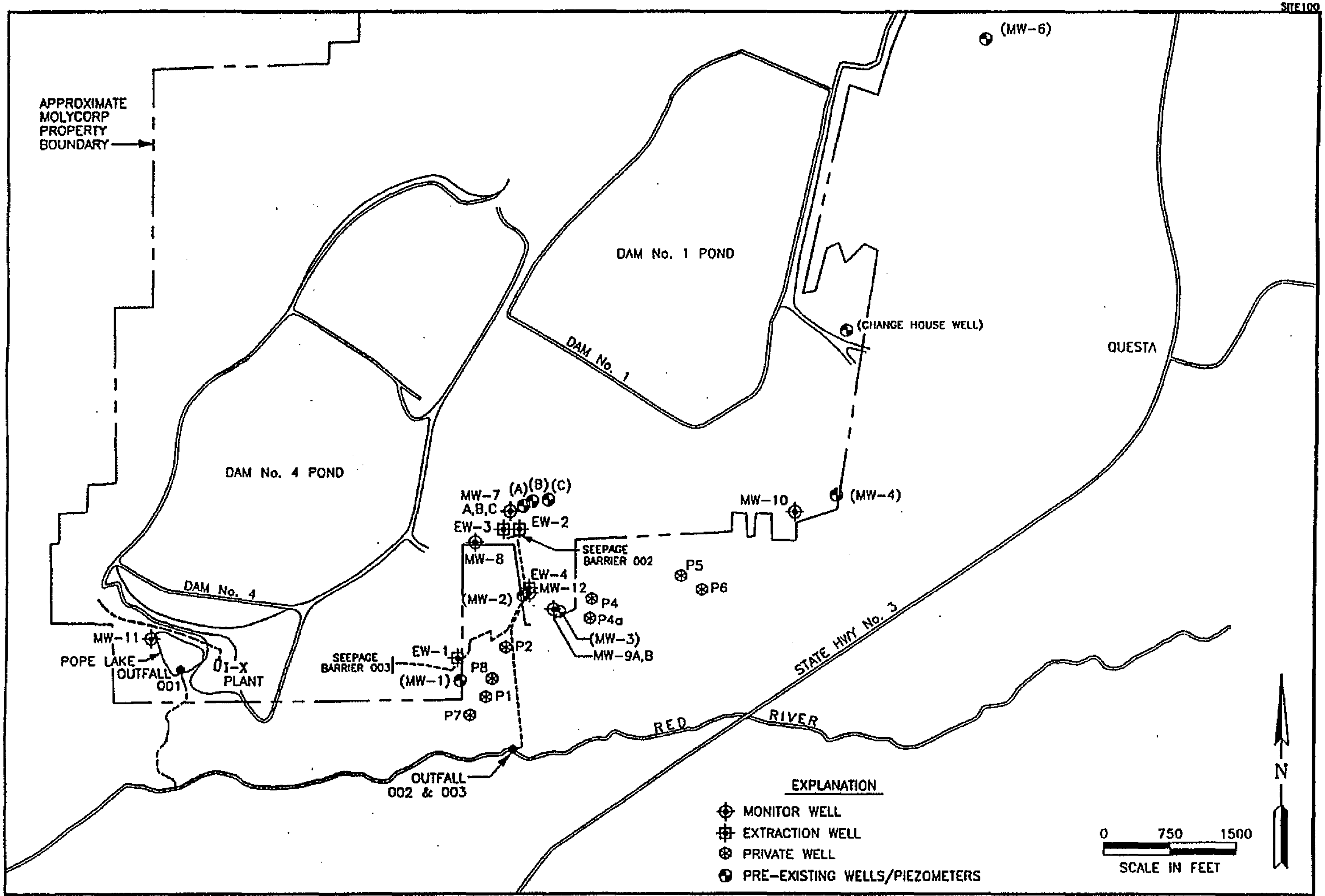


FIGURE: 3

SOUTH PASS RESOURCES, INC.

PROJECT No.:	DATE:	~~AUTHOR:~~	DRAWN BY:
001-05	2/10/95	DAS	M.O'M.

TAILINGS AREA SITE MAP

Molycorp, Inc.
Questa, New Mexico

TABLE 1
1994 MONITOR WELL WATER QUALITY DATA FOR TAILINGS AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 1 of 3)

MONITOR WELL	SAMPLE DATE 1994	WELL TD (feet)	Corrected DEPTH TO WATER (feet)	DEPTH TO PUMP INTAKE (feet)	pH (1)	CONDUCTIVITY (1) (uhmos)	TEMP (1) (°C)	CARBO-NATE (mg/L)	BICARBO-NATE (mg/L)	HYDR-OXIDE (mg/L)	TOTAL ALK (mg/L)	CHLORIDE (mg/L)	FLUORIDE (mg/L)	NITRATE (mg/L)	SUFATE (mg/L)
EW-1	7-Nov	157	83.00	102	7.50	1,460	NA	<1	156	<1	156	23	0.25	0.72	620
EW-2	8-Nov	204	147.91	170	7.48	850	12.9	<1	122	<1	122	4.8	0.49	0.2	96
EW-2	17-Nov	NA	NA	NA	NA	NA	NA	<1	118	<1	118	4.6	0.5	0.38	90
EW-3	8-Nov	78	57.74	70	7.48	1,135	11.4	<1	110	<1	110	17	0.16	0.6	440
EW-3	19-Nov	NA	NA	NA	NA	NA	NA	<1	136	<1	136	18	0.19	0.49	410
EW-4	7-Nov	58	18.49	50	7.78	650	11.6	<1	152	<1	152	26	0.21	0.35	150
EW-4	16-Nov	NA	NA	NA	NA	NA	NA	<1	156	<1	156	26	0.2	0.36	160
MW-1	7-Nov	100	53.17	80	7.28	1,322	NA	<1	136	<1	136	14	0.27	0.45	610
MW-2	7-Nov	80	22.07	60	7.96	1,701	NA	<1	80	<1	80	15	0.96	<0.06	860
MW-3	8-Nov	60	19.97	55	7.38	1,679	12.4	<1	183	<1	183	18	0.44	0.31	780
MW-4	8-Nov	96	40.77	65	7.61	1,157	12.3	<1	184	<1	184	7.3	0.73	0.24	460
MW-7A	7-Nov	90	58.84	80	7.50	1,565	11.9	<1	126	<1	126	16	0.18	0.72	730
MW-7C	9-Nov	146	111.79	135	7.10	2,160	12.4	<1	124	<1	124	16	0.17	0.32	790
MW-9A	8-Nov	44	26.30	35	7.32	1,021	13.1	<1	174	<1	174	20	0.44	0.33	680
MW-10	8-Nov	129	26.23	100	8.16	236	12.3	<1	77	<1	77	1.6	0.36	0.27	35
MW-11	9-Nov	249	191.93	210	7.00	440	19.8	<1	82	<1	82	10.3	1.28	0.39	58
MW-11AB	9-Nov	NA	NA	NA	NA	NA	NA	<1	79	<1	79	10.1	1.29	NA	58
MW-12	7-Nov	234	128.11	210	NA	NA	NA	<1	120	<1	120	5.1	0.46	NA	66
MW-A	7-Nov	38	30.58	NA	7.28	1,332	NA	<1	154	<1	154	14	0.35	0.37	560
MW-C	7-Nov	14.5	1.80	NA	7.24	1,902	NA	<1	185	<1	185	19	1.16	<0.06	970
CH	8-Nov	NA	NA	NA	7.97	539	13.5	<1	206	<1	206	2.3	0.71	0.44	75

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.

SOURCE: SAMPLES TAKEN BY SPRI. ANALYTICAL RESULTS FROM MOLYCORP.

NA - NOT AVAILABLE

TABLE 1
1994 MONITOR WELL WATER QUALITY DATA FOR TAILINGS AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 2 of 3)

MONITOR WELL	TDS (mg/L)	SILVER (mg/L)	ALUMINUM (mg/L)	ARSENIC (mg/L)	BARIUM (mg/L)	BERYLLIUM (mg/L)	CALCIUM (mg/L)	CADMIUM (mg/L)	COBALT (mg/L)	CHROMIUM (mg/L)	COPPER (mg/L)	IRON (mg/L)	MERCURY (mg/L)
EW-1	1,200	<0.10	<0.05	<0.005	0.053	<0.004	240	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-2	240	<0.10	<0.05	<0.005	0.068	<0.004	59.4	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-2	290	<0.010	<0.05	<0.005	0.065	<0.004	57.8	0.0036	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-3	830	<0.10	<0.05	<0.005	0.074	<0.004	179	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-3	750	<0.010	<0.05	<0.005	0.054	<0.004	158	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-4	440	<0.10	<0.05	<0.005	0.065	<0.004	101	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
EW-4	450	<0.010	<0.05	<0.005	0.068	<0.004	104	<0.0005	<0.010	<0.010	0.012	<0.050	<0.0002
MW-1	1,100	<0.10	<0.05	<0.005	0.025	<0.004	207	<0.0005	<0.010	<0.010	<0.010	0.068	<0.0002
MW-2	1,400	<0.10	<0.05	<0.005	0.022	<0.004	241	<0.0005	<0.010	<0.010	<0.010	4.6	<0.0002
MW-3	1,400	<0.10	<0.05	<0.005	0.032	<0.004	264	<0.0005	<0.010	<0.010	<0.010	0.07	<0.0002
MW-4	890	<0.10	<0.05	<0.005	0.084	<0.004	166	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-7A	1,300	<0.10	<0.05	<0.005	0.028	<0.004	273	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-7C	1,300	<0.10	<0.05	<0.005	0.028	<0.004	279	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-9A	1,200	<0.10	<0.05	<0.005	0.061	<0.004	247	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-10	150	<0.10	<0.05	<0.005	0.038	<0.004	28.2	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-11	200	<0.10	<0.05	<0.005	0.014	<0.004	28.6	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-11AB	220	<0.10	<0.05	<0.005	0.015	<0.004	28.5	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-12	260	<0.10	<0.05	<0.005	0.096	<0.004	47.1	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
MW-A	1,000	<0.10	<0.05	<0.005	0.03	<0.004	214	<0.0005	<0.010	<0.010	<0.010	0.066	<0.0002
MW-C	1,700	<0.10	<0.05	<0.005	0.04	<0.004	334	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002
CH	340	<0.10	<0.05	<0.005	0.059	<0.004	48.5	<0.0005	<0.010	<0.010	<0.010	<0.050	<0.0002

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.
SOURCE: SAMPLES TAKEN BY SPRI. ANALYTICAL RESULTS FROM MOLYCORP.
NA - NOT AVAILABLE

TABLE 1
1994 MONITOR WELL WATER QUALITY DATA FOR TAILINGS AREA
MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 3 of 3)

MONITOR WELL	POTASSIUM (mg/L)	MAGNESIUM (mg/L)	MANGANESE (mg/L)	MOLYBDENUM (mg/L)	SODIUM (mg/L)	NICKEL (mg/L)	LEAD (mg/L)	ANTIMONY (mg/L)	SELENIUM (mg/L)	SILICON (mg/L)	THALLIUM (mg/L)	VANADIUM (mg/L)	ZINC (mg/L)
EW-1	3.7	47.9	0.017	<0.02	41.7	<0.020	<0.002	<0.05	<0.005	13.8	<0.005	<0.010	<0.050
EW-2	3.3	10.4	0.169	<0.02	20.0	<0.020	<0.002	<0.05	<0.005	15.7	<0.005	<0.010	<0.050
EW-2	3.6	10	0.138	<0.02	19.6	<0.020	<0.002	<0.05	<0.005	17.3	<0.005	<0.010	0.091
EW-3	2.6	31.8	0.056	<0.02	28.6	<0.020	<0.002	<0.05	<0.005	12.4	<0.005	<0.010	<0.050
EW-3	2.2	27.8	0.036	<0.02	28.9	<0.020	<0.002	<0.05	<0.005	11.9	<0.005	<0.010	0.364
EW-4	1.5	17.8	<0.010	<0.02	15.5	<0.020	<0.002	<0.05	<0.005	12.4	<0.005	<0.010	<0.050
EW-4	2.1	18.1	0.019	<0.02	16	<0.020	<0.002	<0.05	<0.005	12.7	<0.005	<0.010	0.364
MW-1	3.0	41.2	0.035	0.04	55.4	<0.020	<0.002	<0.05	<0.005	11.9	<0.005	<0.010	<0.050
MW-2	3.1	52.2	0.37	1.7	95.6	<0.020	<0.002	<0.05	<0.005	1.8	<0.005	<0.010	<0.050
MW-3	1.5	48.6	0.032	<0.02	71.6	<0.020	<0.002	<0.05	<0.005	10.3	<0.005	<0.010	<0.050
MW-4	1.1	32.7	<0.010	0.21	64.2	<0.020	<0.002	<0.05	<0.005	10.3	<0.005	<0.010	<0.050
MW-7A	2.6	47.1	<0.010	<0.02	39.5	<0.020	<0.002	<0.05	<0.005	12.3	<0.005	<0.010	<0.050
MW-7C	3.9	48.4	<0.010	<0.02	45.1	<0.020	<0.002	<0.05	<0.005	12.1	<0.005	<0.010	<0.050
MW-9A	1.7	45.5	0.111	<0.02	66.0	<0.020	<0.002	<0.05	<0.005	10.5	<0.005	<0.010	<0.050
MW-10	1.3	4.4	<0.010	<0.02	14.7	<0.020	<0.002	<0.05	<0.010	10.8	<0.005	<0.010	<0.050
MW-11	2.8	8.6	<0.010	0.06	25.8	<0.020	<0.002	<0.05	<0.005	15.5	<0.005	<0.010	<0.050
MW-11AB	2.6	8.6	<0.010	0.06	25.7	<0.020	<0.002	<0.05	<0.005	15.5	<0.005	0.01	<0.050
MW-12	2.9	8.5	<0.010	0.02	24.5	<0.020	<0.002	<0.05	<0.005	13.6	<0.005	<0.010	<0.050
MW-A	2.8	35.7	0.04	0.63	50.6	<0.020	<0.002	<0.05	<0.005	10.9	<0.005	<0.010	<0.050
MW-C	2.1	56.1	0.774	1.12	82.2	<0.020	<0.002	<0.05	<0.005	11.6	<0.005	<0.010	<0.050
CH	1.2	9.4	<0.010	<0.02	57.8	<0.020	<0.002	<0.05	<0.005	9.8	<0.005	<0.010	0.946

NOTES:

(1) pH, CONDUCTIVITY AND TEMPERATURE WERE RECORDED WHEN SAMPLED.
SOURCE: SAMPLES TAKEN BY SPRI. ANALYTICAL RESULTS FROM MOLYCORP.

NA - NOT AVAILABLE

TABLE 2
HISTORICAL WATER QUALITY DATA FOR PRIVATE WELLS
TAILINGS AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO

Well #	P-1	P-2	P-3	P-4A	P-4B	P-5	P-6	P-7	P-8	P-9
DATE	1988	1979	1979	1987	1993	1993	1987	1975	1987	1993
Bicarbonate Alkalinity (mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbonate Alkalinity (mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydroxide Alkalinity (mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum (mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic (mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium (mg/L)	<0.01	NA	NA	<0.01	<0.005	<0.005	<0.1	NA	<0.001	<0.005
Calcium (mg/L)	246	NA	NA	128	NA	NA	37	NA	212	NA
Chlorine (mg/L)	21	NA	NA	NA	NA	NA	<5.0	NA	18	NA
Chromium (mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper (mg/L)	<0.01	NA	NA	0.005	0.01	<0.01	NA	NA	<0.1	0.01
Fluoride (mg/L)	0.40	0.50	0.50	NA	0.45	0.42	NA	NA	NA	0.7
Iron (mg/L)	<0.05	0.39	0.13	0.1	<0.05	0.08	<0.1	0.07	<0.1	0.12
Lead (mg/L)	<0.05	NA	NA	<0.05	<0.1	<0.10	<0.1	NA	<0.01	<0.1
Magnesium (mg/L)	39	NA	NA	17	NA	NA	3.0	NA	22	NA
Manganese (mg/L)	0.01	0.03	0.02	NA	<0.01	<0.01	<0.05	NA	<0.05	0.143
Molybdenum (mg/L	0.07	0.02	NA	0.01	<0.005	<0.005	<0.1	2.27	<0.1	<0.005
Potassium (mg/L)	3.0	NA	NA	1.0	NA	NA	4.0	NA	2.0	NA
Redox Pot. (mg/L)	NA	NA	NA	27	NA	NA	NA	NA	NA	NA
Sodium (mg/L)	58	NA	NA	79	NA	NA	9.0	NA	41	NA
Sulfate (mg/L)	763	228	44	358	97	112	32	NA	504	94
TDS (mg/L)	1376	619	345	772	398	276	186	NA	982	270
Zinc (mg/L)	0.08	2.45	0.01	0.64	0.89	0.21	<0.1	NA	<0.1	0.08
pH	7.8	7.4	7.7	7.0	7.5	7.7	7.7	NA	7.1	7.3

KEY TO TABLE 3
LOCATIONS OF WATER SAMPLES
TAILINGS AREA - MOLYCORP, INC. - QUESTA NEW MEXICO

#1	Red River below Highway 38 bridge.
#2	Spring on north side of Red River
#3	Field Drainage to Red River, 500 feet east of Outfall 002
#4	Field Drainage to Red River, 450 feet east of Outfall 002
#5	Red River 300 feet east of Outfall 002
#6	Outfall No. 002
#7	Field Drainage 75 feet west of Outfall 002
#8	Red River above Questa Springs
#9	Near Questa Springs, southeast of concrete box
#10	Near Questa Springs, end of old pipe
#11	Red River 500 feet west of Questa Springs
#12	Spring, north side of Red River Station 47+20
#13	Red River Station 47+70, above Hatchery
#14	Spring south side of Red River Station 36+80
#15	Spring north side of Red River Station 36+40
#16	Red River
#17	Hatchery; cold water inlet
#18	Hatchery; warm water inlet

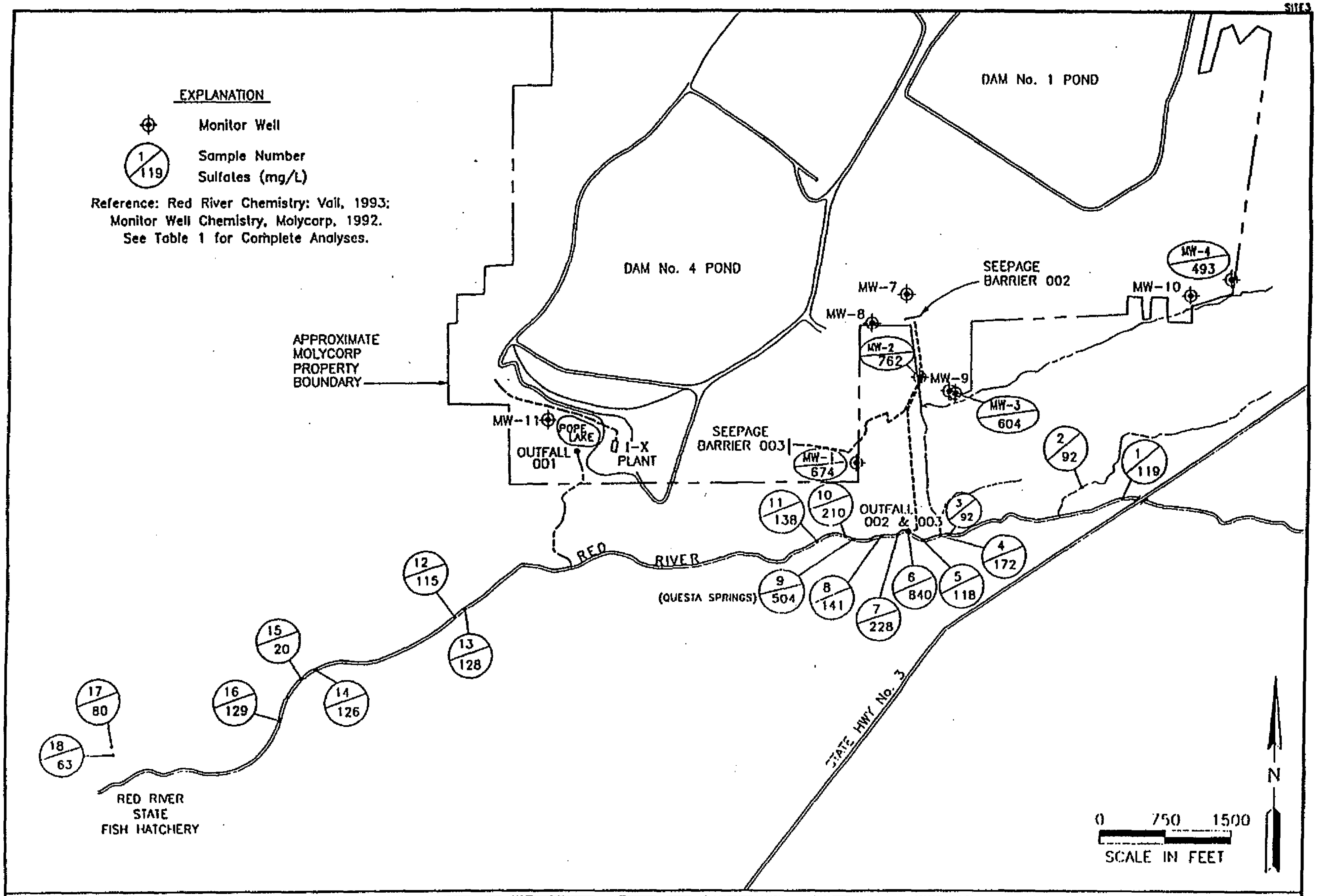


FIGURE: 6

SOUTH PASS RESOURCES, Inc.

PROJECT No.: 001-06

DATE: 3/31/95

AUTHOR:

DRAWN BY: M.O'M.

WATER QUALITY SURVEY: MONITOR WELLS & RED RIVER

Tailings Area – Molycorp, Inc.

Questa, New Mexico

TABLE 3
WATER QUALITY DATA FOR THE RED RIVER (VAIL ENG., 1993)
TAILINGS AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 1 of 2)

Sample Location Number	#1	#2	#3	#4	#5	#6	#7	#8	#9
Total Alkalinity (mg/L)	38	90	99	94	43	152	165	50	158
Dissolved Aluminum (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Suspended Aluminum (mg/L)	7.8	0.50	<0.50	<0.50	8.0	<0.5	2.7	6.2	8.5
Cadmium (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper (mg/L)	0.036	0.007	<0.005	0.008	0.028	<0.005	0.009	0.029	0.016
Fluoride (mg/L)	0.84	0.55	0.60	0.46	0.90	1.90	0.80	0.88	0.38
Iron (mg/L)	0.594	0.543	0.405	0.115	0.569	0.102	1.09	0.573	2.94
Lead (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (mg/L)	0.92	0.02	0.05	0.05	0.88	1.40	0.03	0.88	0.07
Molybdenum (mg/L)	<0.03	<0.03	0.20	<0.03	<0.03	1.80	0.20	<0.03	<0.03
Total Dissolved Solids (mg/L)	255	247	246	648	240	1764	727	268	1094
Total Suspended Solids (mg/L)	31	20	7.0	6.0	22	2.0	39	21	88
Sulfate (mg/L)	119	92	92	172	118	840	228	141	504
Zinc (mg/L)	0.250	0.021	0.047	0.012	0.222	0.010	0.017	0.207	0.047
Temprature (°C)	8.3	10.5	11.2	17.8	9.1	9.7	10.1	9.8	7.8
pH	7.23	6.76	7.44	8.22	7.60	7.26	7.20	7.14	7.02

SOURCE: Vail Engineering (Ralph Vail).
NA - Not Available

TABLE 3
WATER QUALITY DATA FOR THE RED RIVER (VAIL ENG., 1993)
TAILINGS AREA - MOLYCORP, INC. - QUESTA, NEW MEXICO
(Page 2 of 2)

Sample Location Number	#10	#11	#12	#13	#14	#15	#16	#17	#18
Total Alkalinity (mg/L)	177	54	82	51	82	80	49	43	77
Dissolved Aluminum (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Suspended Aluminum (mg/L)	<0.5	3.1	1.7	3.0	<0.50	<0.50	3.1	<0.50	<0.50
Cadmium (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper (mg/L)	0.005	0.033	0.011	0.026	<0.005	<0.005	0.024	<0.005	<0.005
Fluoride (mg/L)	0.60	0.90	0.80	0.90	0.80	1.10	0.90	0.64	0.54
Iron (mg/L)	<0.05	0.618	2.36	0.590	<0.05	<0.05	0.527	0.138	0.181
Lead (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (mg/L)	0.01	0.88	0.13	0.83	0.01	NA	0.781	NA	NA
Molybdenum (mg/L)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total Dissolved Solids (mg/L)	576	269	271	259	304	145	247	176	284
Total Suspended Solids (mg/L)	7.0	22	47	22	<1.0	<1.0	24	NA	NA
Sulfate (mg/L)	210	138	115	128	126	20	129	80	63
Zinc (mg/L)	0.010	0.215	0.046	0.206	0.005	<0.005	0.191	<0.005	0.010
Temprature (°C)	7.1	10.3	15.3	10.5	16.9	16.4	11	8.3	15.8
pH	7.50	7.45	6.94	7.45	8.14	7.26	7.8	7.14	7.87

SOURCE: Vail Engineering (Ralph Vail).
NA - Not Available

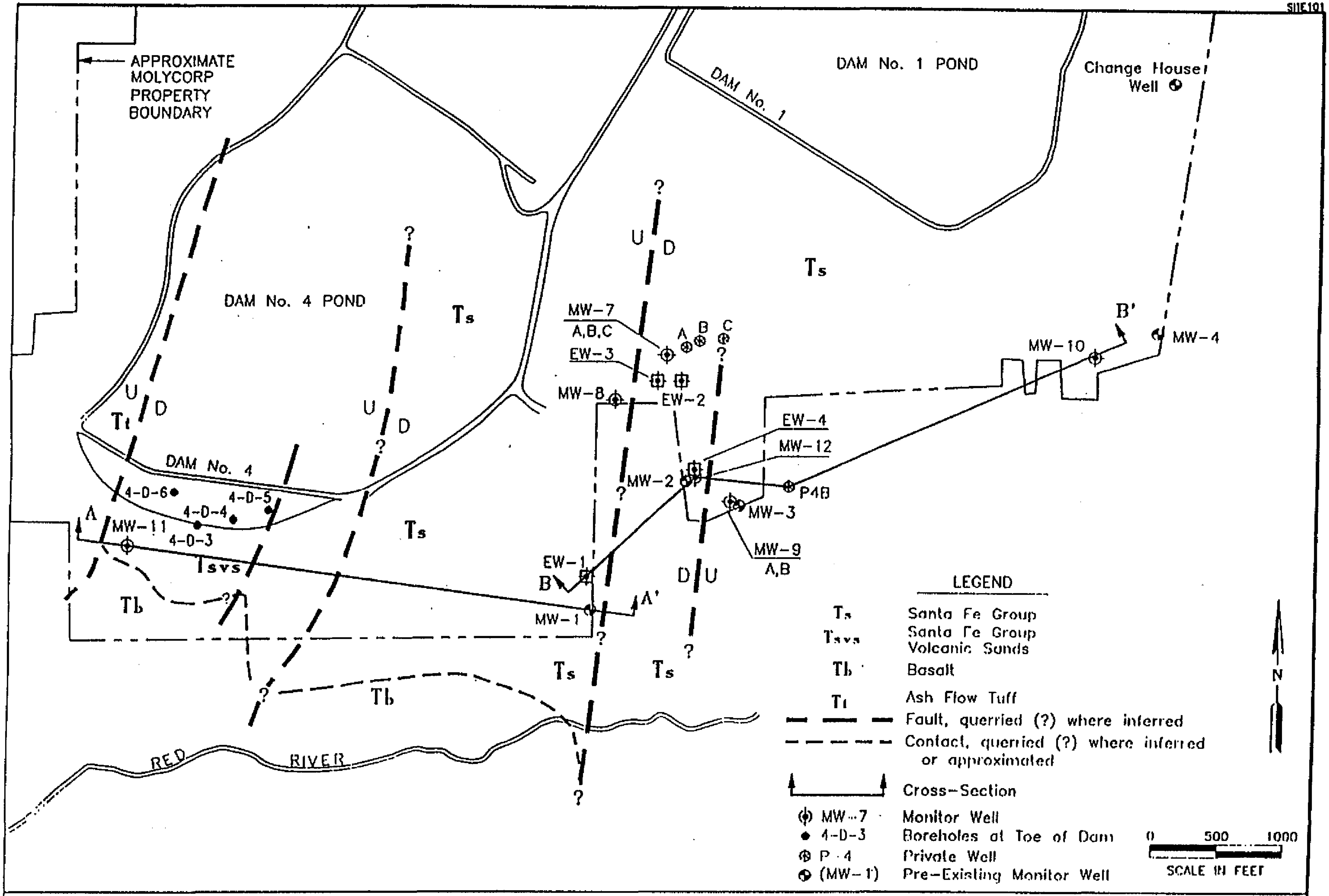


FIGURE: A1

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	3/31/95		M.O'M.

GEOLOGIC MAP – TAILINGS AREA

Molycorp, Inc.
Questa, New Mexico

XSEC-8

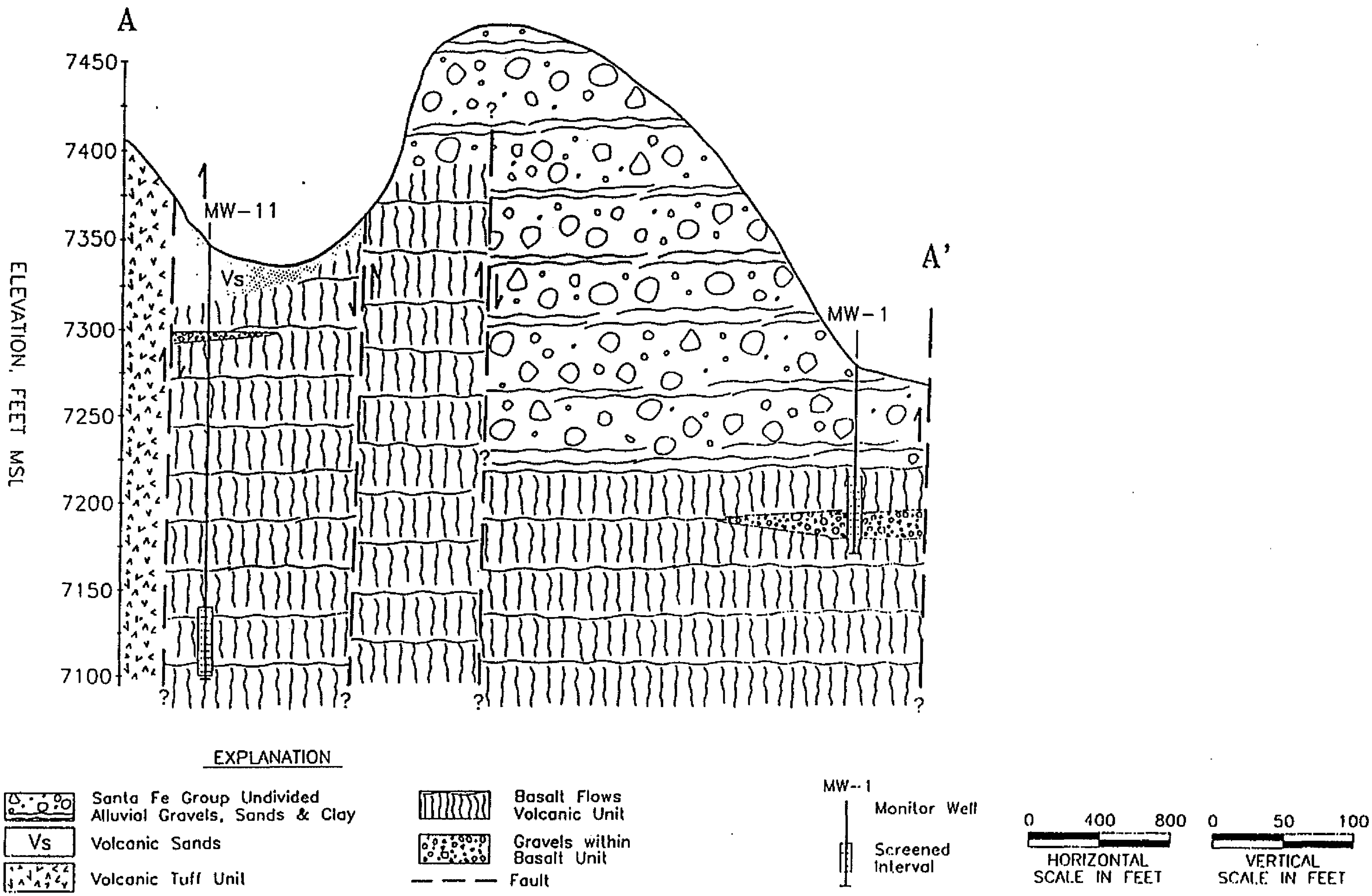


FIGURE: A2	SOUTH PASS RESOURCES, Inc.			
	PROJECT No: 001-06	DATE: 3/31/95	AUTHOR:	DRAWN BY: M.O'M.

GEOLOGIC CROSS-SECTION A - A'

Tailings Area - Molycorp, Inc.
Questa, New Mexico

XSEC-9

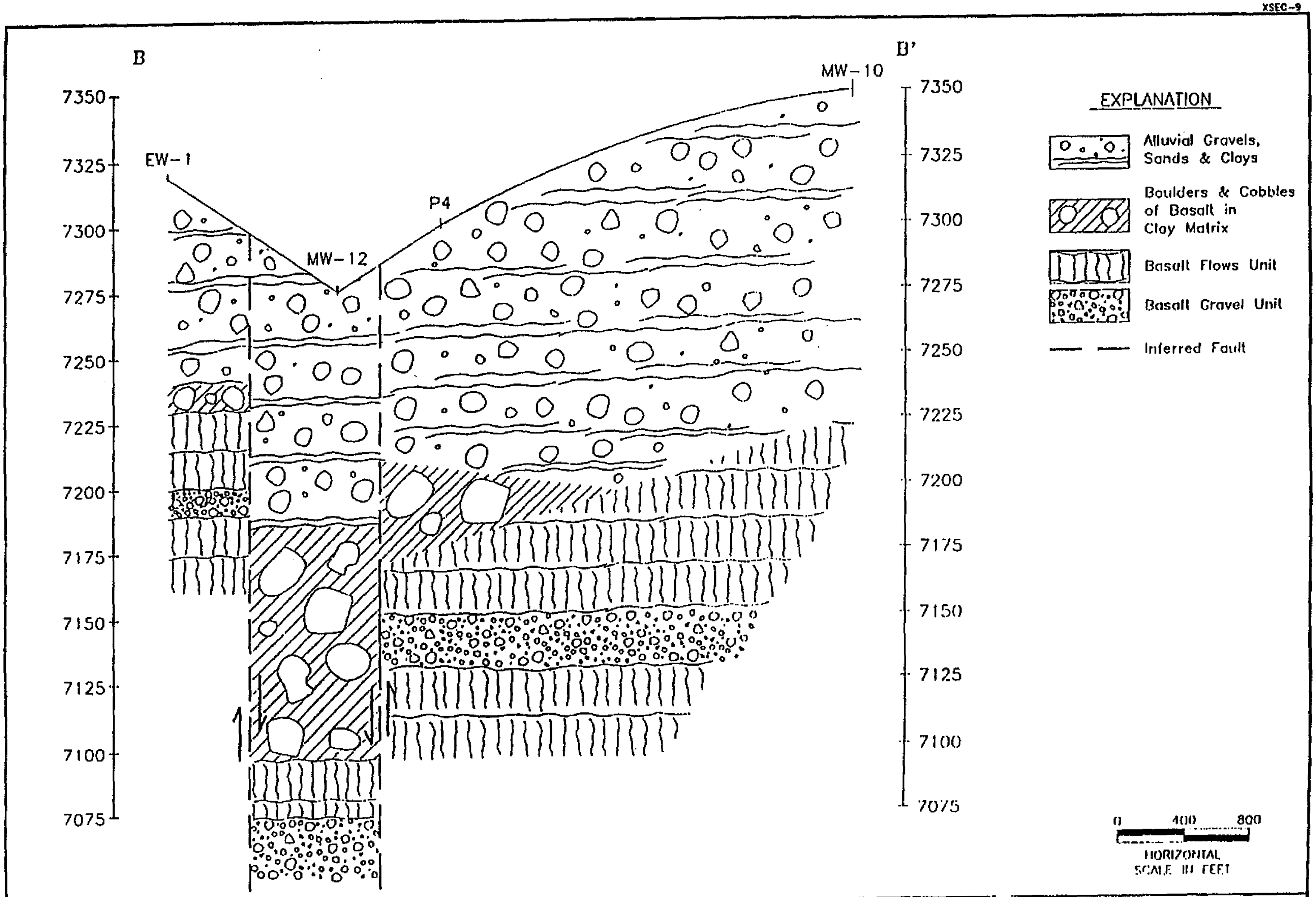
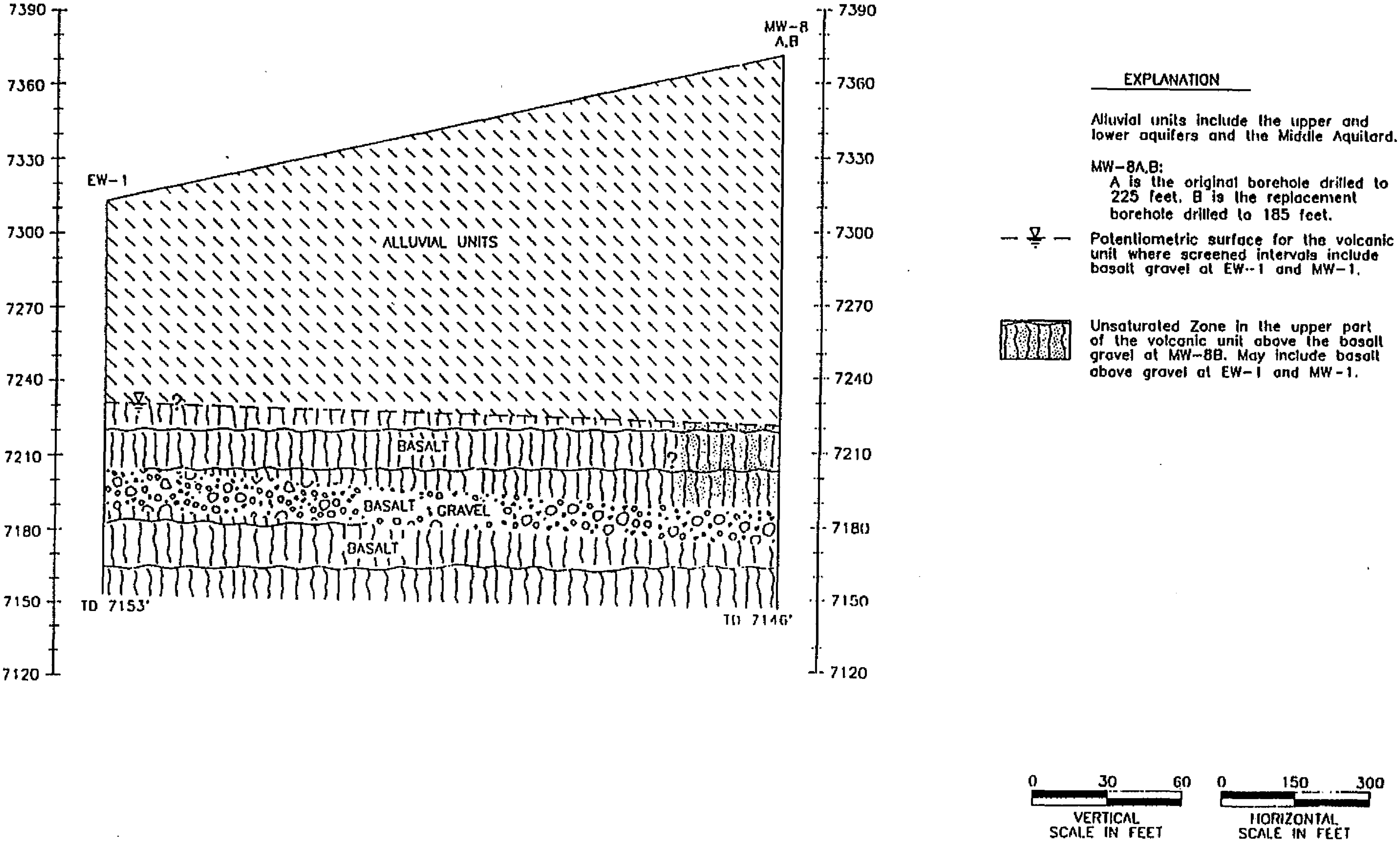


FIGURE:	SOUTH PASS RESOURCES, Inc.				GEOLOGIC CROSS-SECTION B-B' SOUTH OF DAM No. 1
A3	PROJECT No.: 001-06	DATE: 3/31/95	AUTHOR:	DRAWN BY: M.O'M.	Tailings Area - Molycorp, Inc. Questa, New Mexico

XSEC-10



EXPLANATION

Alluvial units include the upper and lower aquifers and the Middle Aquitard.

MW-8A,B:
A is the original borehole drilled to 225 feet. B is the replacement borehole drilled to 185 feet.

— ∇ — Potentiometric surface for the volcanic unit where screened intervals include basalt gravel at EW-1 and MW-1.

▨ Unsaturated Zone in the upper part of the volcanic unit above the basalt gravel at MW-8B. May include basalt above gravel at EW-1 and MW-1.

FIGURE: **B3**

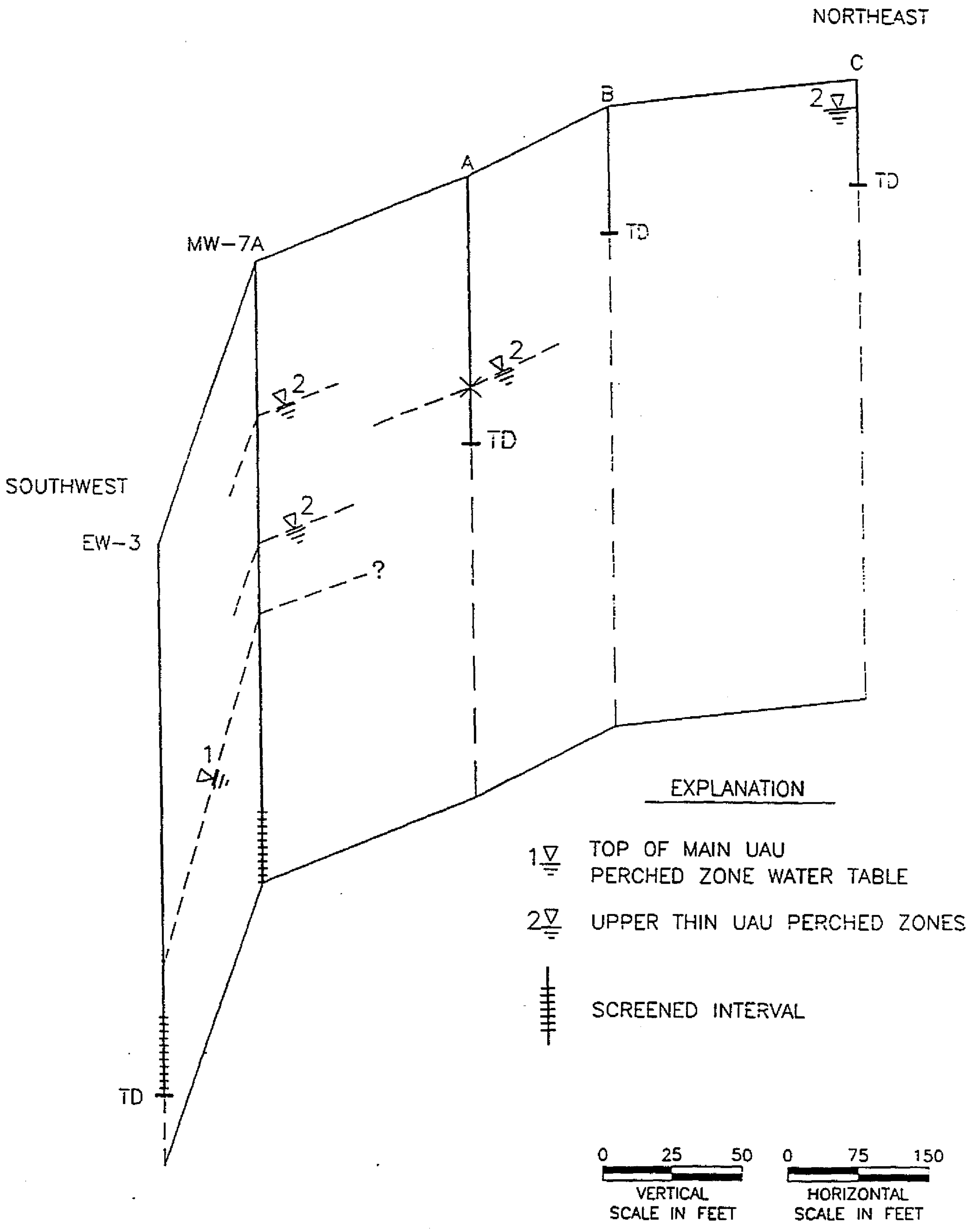
SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	3/31/95		M.O'M.

HYDROGEOLOGIC CROSS-SECTION WEST OF DAM No. 1

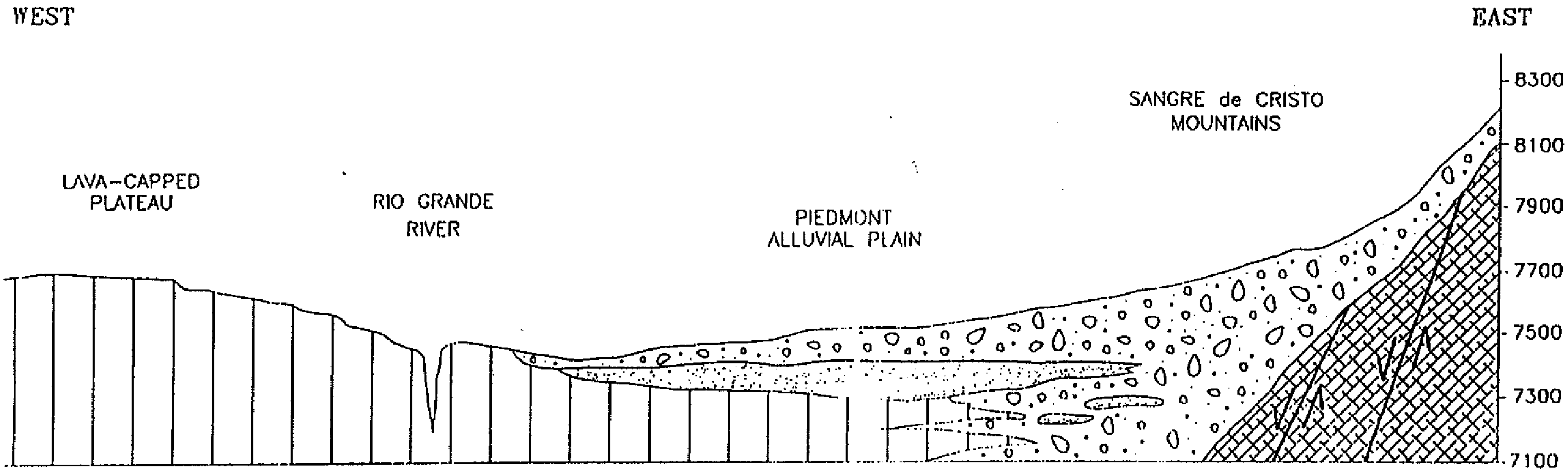
Tailings Area - Molycorp, Inc.
Questa, New Mexico

XSEC-12A



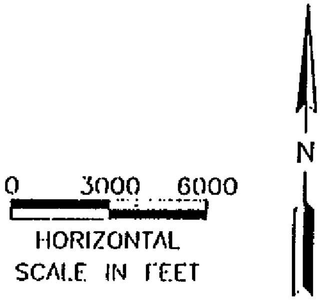
SOUTH PASS RESOURCES, Inc.				HYDROGEOLOGIC CROSS-SECTION SOUTH OF DAM No 1 – Tailings Area Molycorp, Inc., Questa, New Mexico	FIGURE: 5
PROJECT No: 001-06	DATE 3/31/95	AUTHOR:	DRAWN BY: M.O'M.		

SUNSHINE VALLEY, TAOS COUNTY NEW MEXICO



EXPLANATION

∘	ALLUVIAL SEDIMENTS	▥	BASALT/ANDESITIC ASH FLOW TUFFS
⁚	LAKE SEDIMENTS	▩	GRANITIC/GNEISS METAVOLCANIC
⫽	FAULTS		



REFERENCE: MODIFIED FROM WINOGRAD, 1959.

FIGURE: 3	SOUTH PASS RESOURCES, Inc.				GENERALIZED GEOLOGIC CROSS-SECTION Molycorp , Inc. Questa, New Mexico
	PROJECT No: 001-06	DATE: 3/31/95	AUTHOR:	DRAWN BY: M.O'M.	

QUESTA MOLYBDENUM MINE
GEOCHEMICAL ASSESSMENT

Prepared for:

Molycorp Inc.
P.O. Box 469
Questa, New Mexico 87556

Prepared by:

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3232 South Vance Street
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SRK Project No. 09206
April 13, 1995

APPENDIX F

Summary of geochemical assessment for acid rock drainage potential at Molycorp mine, excerpted from SRK Report, April 13, 1995.

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4.0 SUMMARY AND CONCLUSIONS

4.1 Geochemical Properties

4.1.1 Hydrothermal Scars

Samples of hydrothermal scar material collected in and adjacent to the mine site are indicated by static testing to possess significant acid generating potential and by field testing to have acidic paste pH and high conductivity, indicative of a high soluble salt load. The hydrothermal scars produce surface runoff and drainage that is of low pH and contains elevated concentrations of sulfate, fluoride, aluminum, copper, iron, manganese and zinc. Metals that occur in the drainage and runoff from hydrothermal scars include cadmium, cobalt chromium and nickel. Shake flask extraction tests indicate a similar suite of leachable metals exists in hydrothermal scar solid samples.

4.1.2 Mine Waste Materials

4.1.2.1 Waste Rock

4.1.2.1.1 Mixed Volcanic Waste Rock

The waste rock in the various waste rock dumps exhibit variable geochemical properties that are related to waste rock type and source.

Field and static testing indicates acid generating potential, and current acid generation in mixed volcanic waste rock excavated from the area of the Sulphur Gulch hydrothermal scar zone during open pit mining operations. This material was located in the western portion of the pit and remains exposed in the west pit wall. The mixed volcanic waste rock forms the majority of the waste rock placed in the waste rock disposal areas located north, west and south of the open pit.

The mixed volcanic waste rock exhibits drainage chemistry and leachable metals content that are similar in composition to that of the hydrothermal scars. As the mixed volcanic waste rock and hydrothermal scars were subjected to similar geologic processes, the similarity in geochemical properties are anticipated.

The concentration of sulfate and copper, manganese and zinc in drainage derived from the mixed volcanic waste rock is, on average, somewhat elevated with respect to the drainage from hydrothermal scars. This is a result of the high degree of disturbance associated with blasting, excavation and disposal of waste rock that results in favorable conditions for oxidation and ARD generation.

4.1.2.1.2 Black Andesite and Aplite/Granite Waste Rock

Black andesite and aplite/granite form the remainder of the waste rock produced during open pit mining operations. These materials were derived from the south and east sides of the open pit where hydrothermal scar has not been developed. These materials were placed as an armoring cover on the Sugar Shack South, Middle and Spring and Sulphur Gulch waste rock disposal areas. Portions of this material were placed with mixed volcanic waste rock in the in-pit waste rock disposal areas and these materials appear to be the only waste rock type placed in Spring Gulch, and the eastern portion of the Spring and Sulphur Gulch waste rock disposal areas.

Field paste tests indicate that these materials do not nowgenerate acid and static tests indicate they have a low potential to develop acidic conditions. In addition, field tests showed low paste TDS content in black andesite and aplite/granite waste rock. Therefore, these materials have limited potential for leaching of sulfate and metals.

4.1.2.1.3 Other Mine Waste

Other mine waste materials include development rock from the old and new underground mine workings, mine site fill materials, and relic tailings from the old underground mining operation.

Field and static testing of development rock from the old and new underground workings indicates low potential for acid generation. Field tests indicate low paste TDS content and limited potential for leaching of metals and sulfate.

The new mine site area was developed by cut and fill methods. The exposed cut slopes in the mine site indicate that a portion of the fill was derived from areas affected by hydrothermal scar development. Based on field tests, portions of the fill currently exhibit acid generating behaviour and the potential for leaching of metals and sulfate.

The relic tailings from the old underground mining operation were placed at the site of the existing mill. A portion of the relic tailings were used to regrade the mill site prior to facility construction. Field and laboratory testing of relic tailings indicates current acid generating behaviour and the potential for leaching of metals and sulfate.

4.2 Sources of Sulfate and Metals Loads to the Red River

4.2.1 Hydrothermal Scars

The hydrothermal scars in the region represent a mature source of sulfate and metals loads to surface water and groundwater. The oxidation of the scars has been occurring over geologic time and the acidity and metal attenuating capacity of the seepage and flow paths from areas of hydrothermal scar to the river are depleted. The scars are highly erodible. Therefore, the potential for oxidation in hydrothermal scar areas remains relatively constant as surficial materials are removed by erosion, and underlying, unoxidized materials are exposed to oxidizing conditions. The rate of sulfate and metal loading from hydrothermal scars is influenced only by short and long term changes in climatic conditions that control the rates of erosion and the quantity of runoff and seepage from hydrothermal scar areas.

Outside the mine area, hydrothermal scars continue to contribute sulfate and metal loads to the Red River as they have over geologic time. Within the mine area, the majority of seepage and runoff from areas affected by hydrothermal alteration is collected in the underground mine. The scar impacted drainage and runoff collected in the underground mine is now being pumped to the tailings impoundment west of the town of Questa to dewater the underground mine. Therefore, the seepage and runoff from scar areas collected in the mine has no impact on the quality of water in the Red River.

In the mine area, drainage from several areas of hydrothermal scar are not collected in the underground mine and may still contribute to the sulfate and metals concentrations in the Red River. Hydrothermal scars occur under a cover of waste rock in the Sugar Shack South, Middle and Spring and Sulphur Gulch waste rock disposal areas. While surface runoff and sediment generation from these areas are controlled by Molycorp's surface water management facilities, the subsurface flow paths from these areas have not been substantially altered by the mining operation. Hydrothermal scars also occur adjacent to the Red River in the area between the mine site and the mouth of Capulin Canyon. The potential for the contribution of sulfate and metal loads from these sources has not been reduced or increased by the mining operation.

4.2.2 Mine Waste Materials

The drainage and runoff from waste rock placed in the in-pit waste rock disposal areas is currently collected in the open pit and drains to the new underground mine, and has no impact on the quality of water in the Red River.

At several locations, the potential for contributions of sulfate and metals from mine waste to the Red River exists.

Seepage from the Capulin waste rock disposal, together with seepage and runoff affected by hydrothermal scars located in Capulin Canyon, potentially migrates down Capulin Canyon as subsurface flow.

Subsurface seepage from the new mine site, the mill site and the Sugar Shack South, Middle and Spring and Sulphur Gulch waste rock disposal areas are currently not controlled by Molycorp's seepage collection systems. Acid generating materials in these areas have the potential to contribute sulfate and metals loads to the Red River.

In contrast to the hydrothermal scars, the mine waste at Questa represents a new source of sulfate and metal loads. Testing of the alluvial and colluvial materials located below the waste rock disposal areas adjacent to the Red River indicates a limited but measurable ability for attenuation of acidity. Therefore, contaminated mine waste drainage may still be buffered along the seepage path to the Red River and the current water quality as indicated by springs and seeps may not represent mine waste drainage quality. The location of the contaminant fronts of seepage plumes from these areas is currently unknown. Moreover, since the chemistry of the hydrothermal scar and mine waste impacted drainage is similar in composition, the relative contributions of these sources cannot be identified.

4.3 Long Term Climatic Effects on Water Quality

As previously mentioned, the hydrothermal scars in the region represent a mature and relatively constant source of sulfate and metal loads to regional and local surface water and groundwater resources. However, these sources are influenced by climatic conditions and during extended periods of above average precipitation, loading from these sources can be anticipated to increase as a result of increased erosion, runoff and infiltration. Conversely a reduced loading is expected during periods of prolonged drought.

From 1961 to 1991, the average annual discharge at the Questa gaging station was 40.4 cfs. This period spans the life of the open pit and new underground mining operations at Questa when water was diverted for mill use. In the period between 1961 and 1978, average annual discharge at the Questa gaging station was 33.1 cfs while from 1978 to 1993, the average annual discharge was 52.2 cfs. These large changes in average flow rates are expected to have associated substantial erosion and seepage from scar material, resulting in large natural fluctuations in the mean annual contaminant loading to the Red River.

Because of the change in climatic conditions the "background" water quality data from 1965 may not be representative of that for 1993. Indeed it may be anticipated that the average natural contaminant loads to the Red River in the first half of the 1990's would be substantially greater than the average loading experienced in the first half of the 1960's.

5.0 RECOMMENDATIONS FOR NEXT PHASE OF INVESTIGATION AND CHARACTERIZATION

5.1 Requirements for Additional Investigation and Characterization

This initial mine waste rock investigation and characterization has served to identify the current and potential sources of the contaminant drainage to the Red River. It has been established that contaminant sources exist both as exposed sulfitic rocks in the waste rock dumps and open pit. This investigation focused mainly on the identification and qualitative characterization of these sources and the contaminant migratory routes to the Red River. A relatively good understanding of the qualitative characteristics has been developed for:

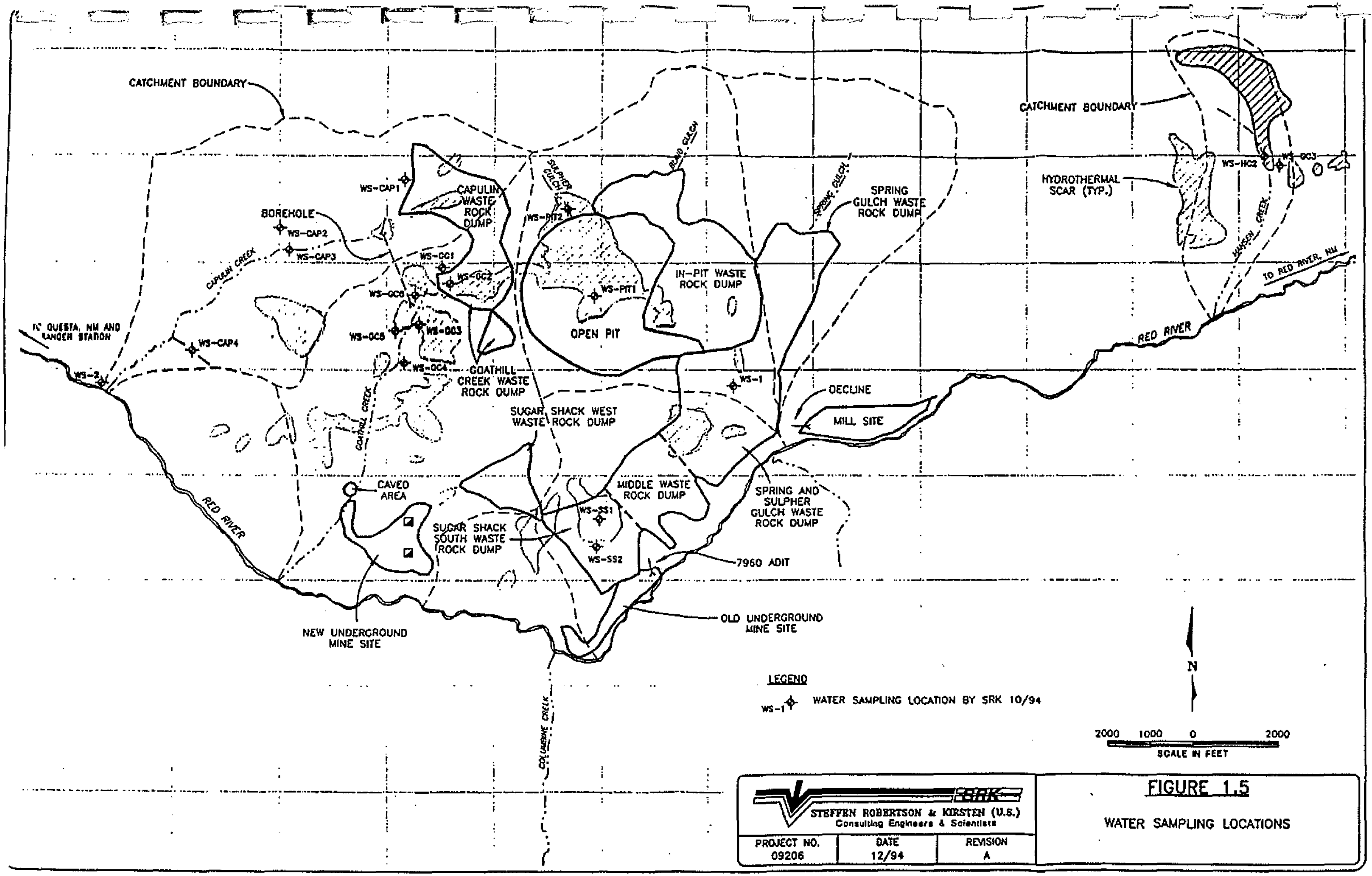
- The locations from which contaminated drainage is originating for both natural and mine induced drainage;
- the current quality of the pore water in these sources;
- the lithological and geochemical characteristics of the rock from which the contaminants originate;
- the surface flow and seepage pathways along which the contaminated drainage migrates;
- the physical and geochemical controls along the migratory routes; and
- the quality of surface and ground water discharges to the Red River and the contaminant loads in the Red River.

In the next phase, investigation of mine waste rock should attempt to extend this qualitative understanding to be more quantitative in regard to the characterization of the rock contaminant flow paths, and to both current and long term contaminant load generation and migration. Aspects to be investigated and characterized may be divided into four groups:

i) The definition of the quantities, and distribution of ARD characteristics of waste rock in the various dumps and portions of dumps, construction embankments and rock cuts on the mine disturbed site. This investigation should extend the current surficial survey to define conditions at depth within the deposits. This quantification and extension will be based on a detailed review of the mine plans and dump development records, additional surficial surveying and limited drilling to determine the rock characteristics at depth.

ii) The definition of the conditions other than rock characteristics controlling acid generation in the waste piles. This includes determining water and oxygen entry and distribution, and temperature conditions in the waste rock piles.

An understanding of the oxygen distribution in the piles indicates the zones where acid generation is occurring or is inhibited. It provides an understanding of the likely long term conditions which will control acid generation both without and with the addition of oxygen entry control measures such as covers.



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STEFFEN ROBERTSON & KIRSTEN (U.S.)
Consulting Engineers & Scientists

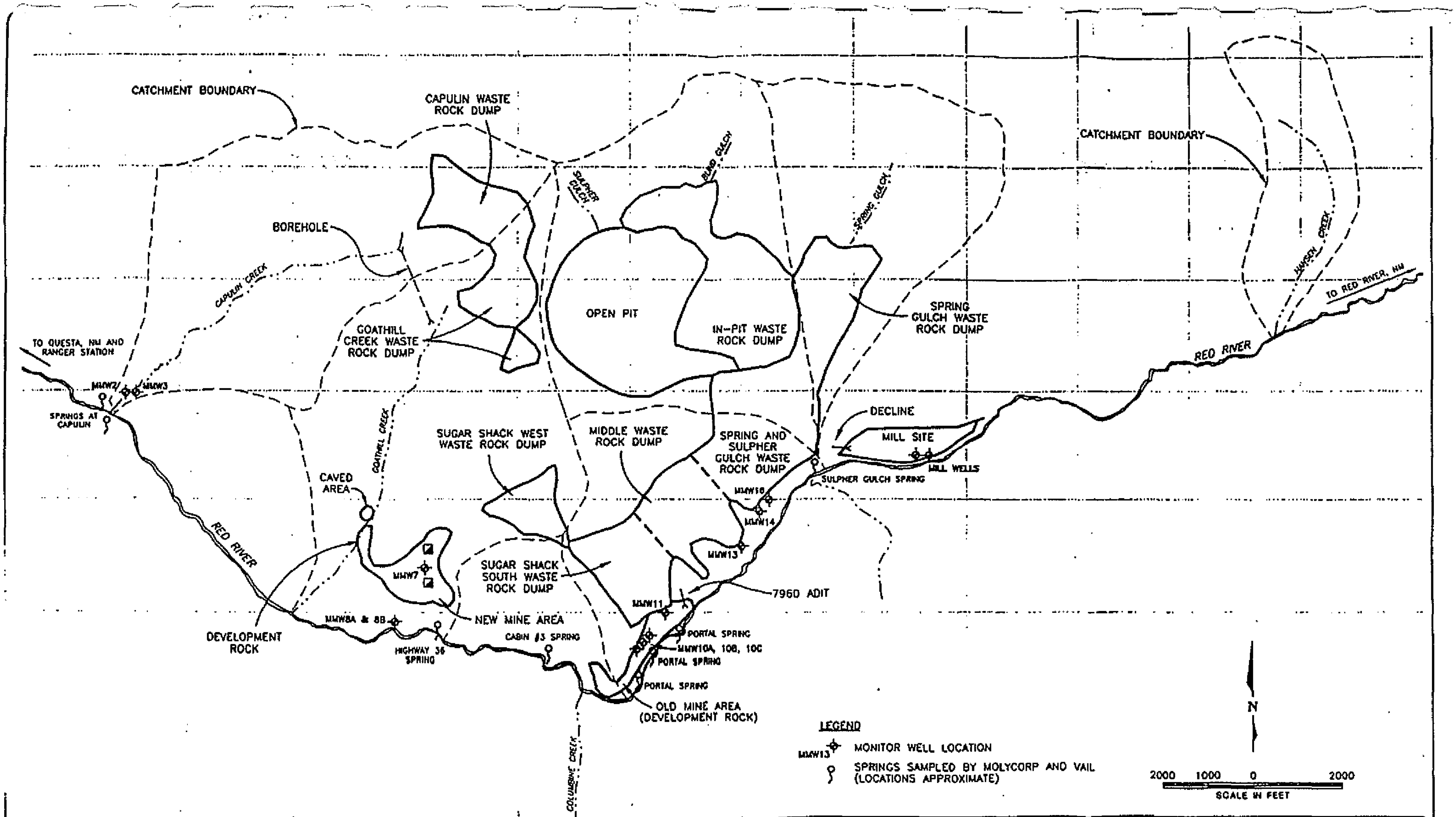
PROJECT NO.	DATE	REVISION
09206	12/94	A

FIGURE 1.5

WATER SAMPLING LOCATIONS

APPENDIX G

Selected tables and figures pertaining to Red River water quality from Garrabrant, 1993, USGS Water Resources Investigation Report 93-4107.



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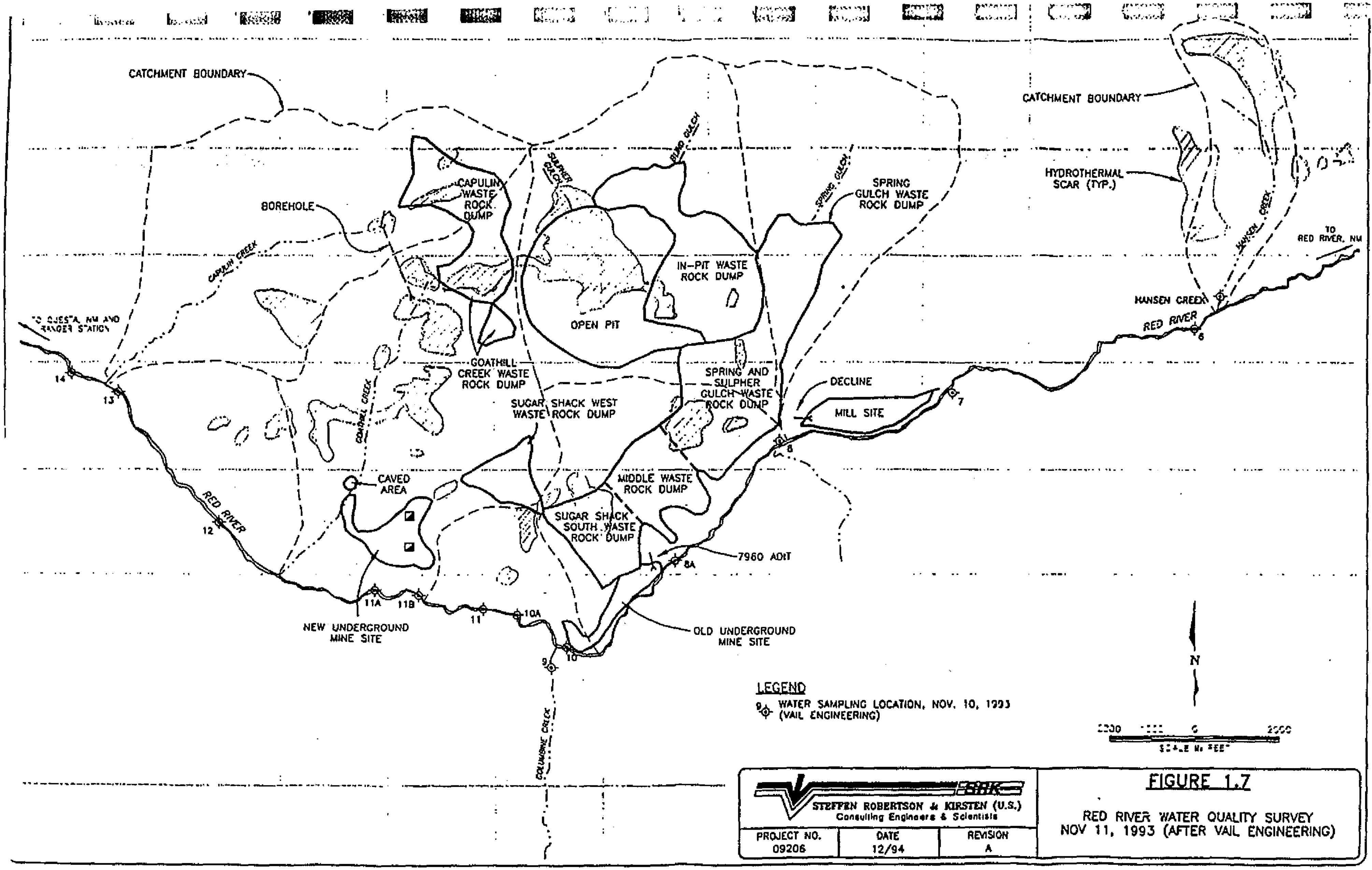
09206	12/94	A

FIGURE 1.6

MONITOR WELL AND SPRING LOCATION PLAN



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09206	12/94	A

FIGURE 1.7

RED RIVER WATER QUALITY SURVEY
NOV 11, 1993 (AFTER VAIL ENGINEERING)

TABLE 1.2
Summary of 1994 Water Quality Data Collected from Seeps and Streams around the Questa Mine

	Background* (N=1)	Undisturbed Scar Material ** (N=8)				Disturbed Scar Material*** (N=9)			
		Mean	Median	Minimum	Maximum	Mean	Median	Minimum	Maximum
pH	6.9	2.774	2.725	2.33	3.2	3.09	3.12	2.58	3.63
Conductivity (μmhos)	409	3996	3865	1350	6830	5038	3390	1600	12300
Acidity (mg $CaCO_3$ eq./L)	14.2	2517	1933	326	5350	3432	856	435	12200
Alkalinity (mg $CaCO_3$ eq./L)	41	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SO_4 (mg/L)	140	3018	2360	735	5900	4395	2500	976	12700
Al (mg/L)	18	229.6	173.8	50.3	582	471	138	6.37	1850
Cd (mg/L)	<0.01	0.026	0.01	<0.01	0.092	0.14	0.021	0.01	0.585
Co (mg/L)	0.018	0.484	0.234	0.04	1.63	1.238	0.511	0.187	4.45
Cr (mg/L)	<0.015	0.077	0.0585	<0.015	0.218	0.162	0.067	<0.015	0.495
Cu (mg/L)	0.094	2.191	1.23	0.022	7.25	3.89	2.31	0.19	13.9
Fe (mg/L)	17.2	316.7	183.5	6.83	890	230	59	3.66	848
Mo (mg/L)	<0.03	0.036	0.03	<0.03	0.079	0.099	0.03	<0.03	0.615
Mn (mg/L)	3.62	31.21	18.85	2.33	87.4	210	59.6	4.7	787
Ni (mg/L)	0.042	1.196	0.5395	0.107	4.08	2.54	0.97	0.369	9.43
Pb (mg/L)	0.146	0.104	0.05	<0.05	0.437	0.184	0.05	<0.05	1.04
Zn (mg/L)	0.527	7.177	4.59	0.498	20.6	36	8.01	1.86	132

Notes: All metal concentrations are total; dissolved concentrations are listed in Table C2, Appendix C. N = Number of Samples

*Sample: WS-Cap2

**Samples: WS-GC3, WS-GC4, WS-GC5, WS-GC6, WS-HC1, WS-HC2, WS-Pit2, WS-Cap4

***Samples: WS-1, WS-2, WS-Cap1, WS-Cap3, WS-GC1, WS-GC2, WS-SS1, WS-SS2, WS-Pit1

(from SRK report - 4-13-95)

APPENDIX H

Report on installation of anoxic limestone drains at Red River and Capulin Canyon in October, 1995.

Anoxic Alkaline Drain Treatment of Seeps Entering the Red River

By
Michael W. Coleman
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Surface Water Quality Bureau-Nonpoint Source Pollution Section
P.O. Box 26110, Room N-2101, Santa Fe, NM 87502

Abstract

The New Mexico Environment Department (NMED) conducted a two-year water quality investigation, funded in part by a U.S. Environmental Protection Agency 319(h) Grant, along the Red River, Taos County, New Mexico. The project culminated in a cooperative field demonstration project to mitigate and prevent future impacts of highly acidic, metal-loaded ground water seeps entering the Red River, near Questa. The NMED - Surface Water Quality Bureau, Nonpoint Source Pollution Section identified a number of sites where springs or perennial seeps deliver acid rock drainage via ground water which has been in contact with sulfide-rich hydrothermal rock scar areas or mine waste piles within the watershed. The seeps have a direct impact on the physical and chemical water quality and thereby effect the designated uses of the waterway. In-stream impacts include stream acidity, precipitation of calcium-aluminum cements, impairment of macroinvertibrate and fish habitat, and transport of a variety of dissolved and suspended heavy metals.

The field project involved the installation of selected Best Management Practices (BMPs) consisting of a set of Anoxic Alkaline Drain Passive Treatment Systems at a site along the Red River where several of the seeps are particularly active. One hundred seventy lateral feet (170') of trenches were dug below the local ground water level. The trenches were filled with limestone cobble, capped with a layer of clay, and reclaimed to road shoulder grade. Physical parameter and water chemistry monitoring is underway to measure an anticipated increase in pH levels and a corresponding decrease in the heavy metal content of the seeps. Favorable results may point the way to implementing this technology on several sites in this watershed, and around other abandoned mine or mill sites, or geologically active source areas throughout the state where acid rock drainage presents a pollution problem.

The project was a cooperative effort between NMED (project inception, design, coordination and follow up monitoring), the Unocal Molycorp Questa Molybdenum Mine (donated materials, equipment, and labor), the State Highway and Transportation Department (labor, heavy equipment and safety crews) and the Questa Ranger District, Carson National Forest (permitting).

Introduction

The Red River region of northern Taos County, New Mexico is recognized as one of the most beautiful tourist destinations and popular multiple use areas of our state. Visitors flock there in summer and winter for the recreation opportunities such as camping, skiing, hiking, back country touring, and of course, fishing. Environmental scientists, sportsmen, activists and local residents are concerned about environmental conditions threatening or impacting the region. Many citizens, including some of those in attendance at this ***1996 NM Conference on the Environment***, are involved with projects to improve and protect various aspects of the watershed. New Mexico Environment Department (NMED) staff participate in monitoring and field implementation projects and are responsible for municipal and industrial air and water quality permitting issues in the region. This paper presents information on attempts to mitigate particular aspects of nonpoint source pollution (NPS) of surface and ground waters by addressing acidic, metal-loaded seeps entering the river.

Location of study area

The Red River's headwaters begin as springs and snow melt from the highest terrain in the state. Beginning in the northern and eastern sides of the Wheeler Peak Wilderness (Figure 1), the river accumulates the flow from twenty one perennial tributaries along its route through the Taos Mountains of the Sangre De Cristo Range, westerly down to the Taos Plain and the Rio Grande Rift. Covering an area of 226 square miles, it is a major tributary watershed to the upper Rio Grande system. The site of this demonstration project lies in the middle reach of the river, between the towns of Red River and Questa (Figures 1 and 2), near the confluence of the Red River with Capulin Canyon, to the north, and Bear Canyon to the south.

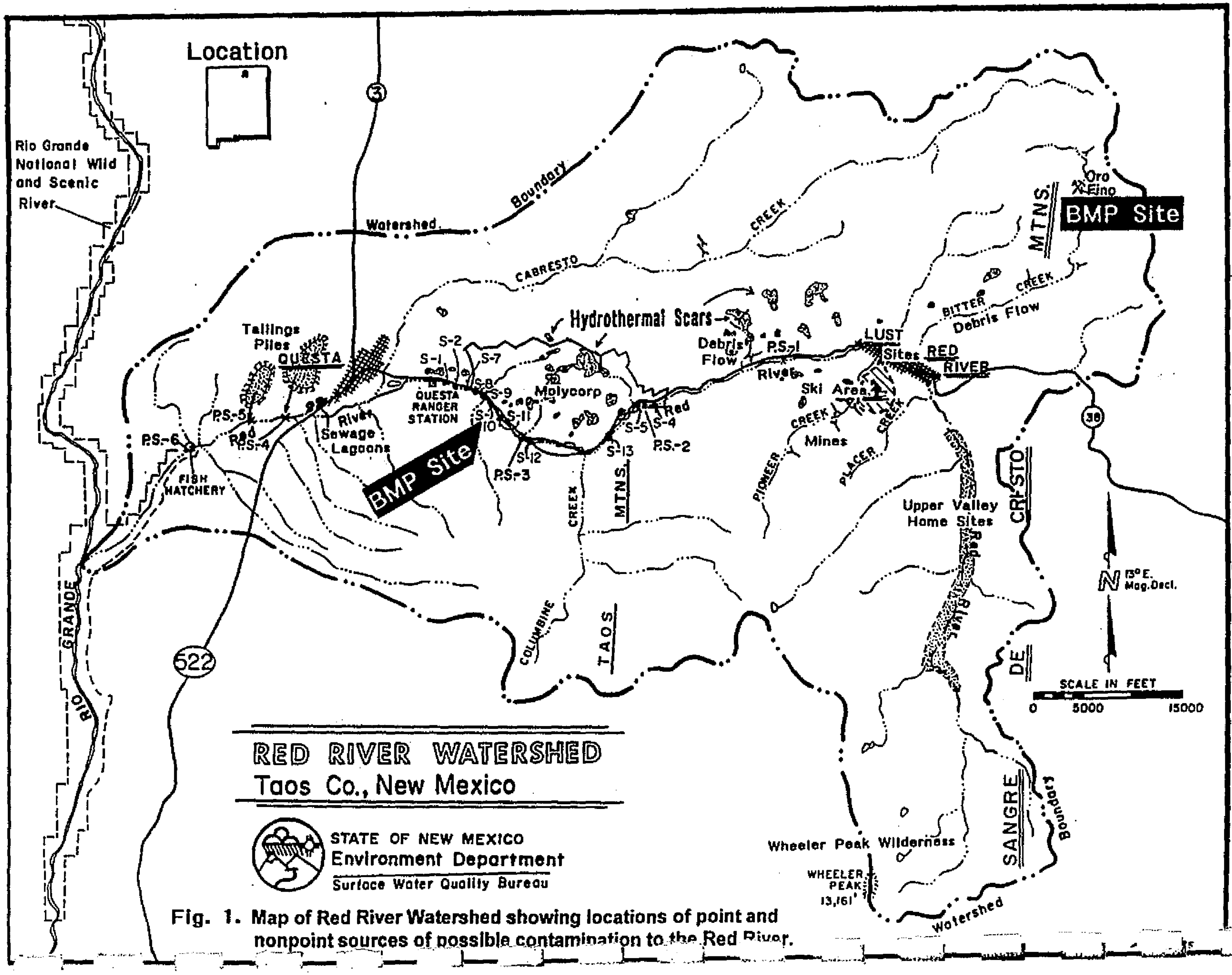


Fig. 1. Map of Red River Watershed showing locations of point and nonpoint sources of possible contamination to the Red River.

EXPLANATION

POINT SOURCE POLLUTION:

PS-1: Town of Red River Wastewater Treatment Plant

PS-2: Molycorp Mill Site Outfall #005

PS-3: Molycorp Mine, Goathill Gulch Outfall #004

PS-4: Molycorp East Tailings Pile Outfall #002

PS-5: Molycorp Pope Lake/W.Tailings Outfall #001

PS-6: Red River Fish Hatchery (NMDG&F)

NONPOINT SOURCE POLLUTION:

S-1 to S-13: Red River Groundwater Seeps (ARD)

Hydrothermally Altered Volcanic Rock Scars

Molycorp Mine

Scattered Abandoned Mine and Mill Sites (Esp. Pioneer and Bitter Creeks)

Upper RR Valley Home Sites: septic tanks, leach fields

Town of Red River: Leaking Underground Storage Tanks (LUST)

Red River Ski Area

Town of Questa Sewage Lagoons

Landslide/ Debris Flow Gravels and Sediments (Bitter, Hansen and Hotentot Creeks)

Background

In past years the Red River gained fame as one of the premiere trout fishing streams in the nation. The ground water resources of the area were known to be of the highest quality. Prior to mid-1960s, polluted surface water was rare, except during seasonal storm events when turbidity and sudden spikes of soil-derived metals temporarily contaminated the waters. As urban development and tourism increased and the local mining, cattle ranching and timber industries matured in the region, the impacts on surface and ground water quality have overwhelmed the Red River. Presently the watershed's designated or attainable uses as a high quality coldwater fishery, and source for livestock/wildlife watering and irrigation waters are not being met (NMWQCC, 1994). Environmental concerns include effluent from septic tanks and leach fields, leaking underground storage tanks, low pH levels, siltation, heavy metal loading in the stream from acid drainage, and loss of biological and riparian habitat (Slifer, 1996; Figure 1).

The headwater areas remain mostly high quality sources but the water delivered downstream into the Rio Grande is not as clear and clean as it once was. Several miles below the Town of Red River the water is frequently a distinctive cloudy blue-gray color, indicative of a highly stressed waterway. The lowermost reaches, designated as a part of the National Wild and Scenic Rivers System, have recovered as a spawning ground for big brown and cutthroat-rainbow trout, primarily due to stream dilution of pollution effects, but a variety of upstream NPS impacts, as well as seasonal turbid flood events, still threaten the river.

Identification of impacts

The Red River watershed has become the focus of several field projects implemented by the NMED-Surface Water Quality Bureau (SWQB). The investigations are aimed at identifying, controlling or preventing NPS problems associated with mining impacts, ground water quality and stream channel restoration. During a recently completed two year project, funded in part by a Grant from the Environmental Protection Agency (EPA), the investigators evaluated the quality of the ground water which recharges the gaining Red River. Sources of impact were identified and corrective procedures known as Best Management Practices (BMPs) were designed and implemented. Project Manager Dennis Slifer sampled the various tributary stream sources and ground water wells along the main stem of the Red River and identified a number of sites where metal-loaded, acidic waters seep into the Red River. Approximately ten seeps were monitored for chemical changes through time. His conclusions are presented in a Final Project Report to the EPA Region 6, in preparation (Slifer, 1996).

Beginning below Cabin Spring, near the confluence of Columbine Creek, the river develops a milky blue-gray color due to an excess of dissolved and suspended heavy metals entering the river from both overland and spring or seep sources. Physical parameters such as pH and conductivity deteriorate within the same zone. Metals are mobilized from upland sources when oxygenated acidic waters contact sulfide-rich bedrock, soils or mining wastes. In the stream, the buffering capacity of the river assists in neutralizing the acid and the metals slowly precipitate out. Along certain river segments a white pasty material composed of calcium, aluminum and silicon accumulates on the stream bottom near where acidic spring or seep waters merge with stream flow. The compound contains *gibbsite* (aluminum hydroxide phyllosilicate). It effectively cements the stream bottom, sealing the substrate where macroinvertebrate insect life struggles to survive. While not technically "biologically dead", reaches accumulating this paste are very heavily impacted. Only high seasonal flows can temporarily scour the substrate clean. Fish are unable to thrive due to chemical stresses and lack of food. Currently there exists an absence of a reproducing fish population and a lack of favorable benthic habitat, except near the confluence with the Rio Grande. It was decided a BMP should be attempted to address both the geochemical and biological impacts.

Probable Sources of Contamination

A combination of interrelated geologic conditions and industrial practices very likely contributes to the development of the acid seeps. The complex geological setting involves Proterozoic metamorphic basement overlain by Tertiary sediments and intermediate volcanics. Episodes of caldera subsidence and injection of granitic plutons followed. Structurally, the area has been faulted, tilted and uplifted in response to Rio Grande rift extension. The intrusions were responsible for hydrothermal (hot water) alteration and significant ore mineralization in this district. Past mining operations for precious and base metals are scattered throughout the watershed. The Questa Molybdenum Mine dominates the landscape with its attendant open pit, waste rock piles, exposed ore-bearing zones, and the milling and tailings disposal facilities. There are numerous opportunities for degradation of water quality near a mining operation of this size, especially considering the mode of disposal of waste rock employed in the past. The management of the Questa Mine, while not taking responsibility for pollution problems along the Red River, is cooperating by monitoring and mitigating possible mine site pollution sources. They are collecting acidic seepage from waste piles, diverting it to the underground mine area. They have installed a set of monitor wells around the mine and tailings pile sites. Molycorp showed interest in NMED's demonstration project in order to determine if passive treatment systems should be constructed on their property for treatment of leachate from waste rock piles.

Additionally, the volcanic outcrop areas host a number of large and colorful ridges and hillside scars which are natural geological exposures of the hydrothermally altered rocks. Meteoric-hydrothermal systems related to the intrusions altered felsic volcanics to clay and deposited high grade pyrite (to 3%) in permeable host rocks (Meyer and Leonardson, 1990). The steep scar areas are a significant source of NPS pollution, yielding sulfidic sediments during storm events and releasing their naturally occurring ARD. Weathering promotes iron oxide formation and exposes new layers of sulfide-rich clays and altered volcanics which gravitate to the gentler slopes and stream bottoms. Vegetation rarely gains a foothold.

Current field work suggests the erosion of many of the natural scar areas was greatly accelerated by man's relatively recent activities: gold and molybdenum prospecting, establishing exploration drill roads, cutting adits and shafts into the colorful exposures of altered materials. Many recreational four-wheel drive roads and trails cut into these or similar materials, with the effect being erosion and runoff access to additional metal-rich soils and bedrock. There are "control" scars which appear to be untouched and these sites are not eroding on the same scale.They emit only occasional acidic runoff, far less than is seen in the prospected or traveled-over scar areas.

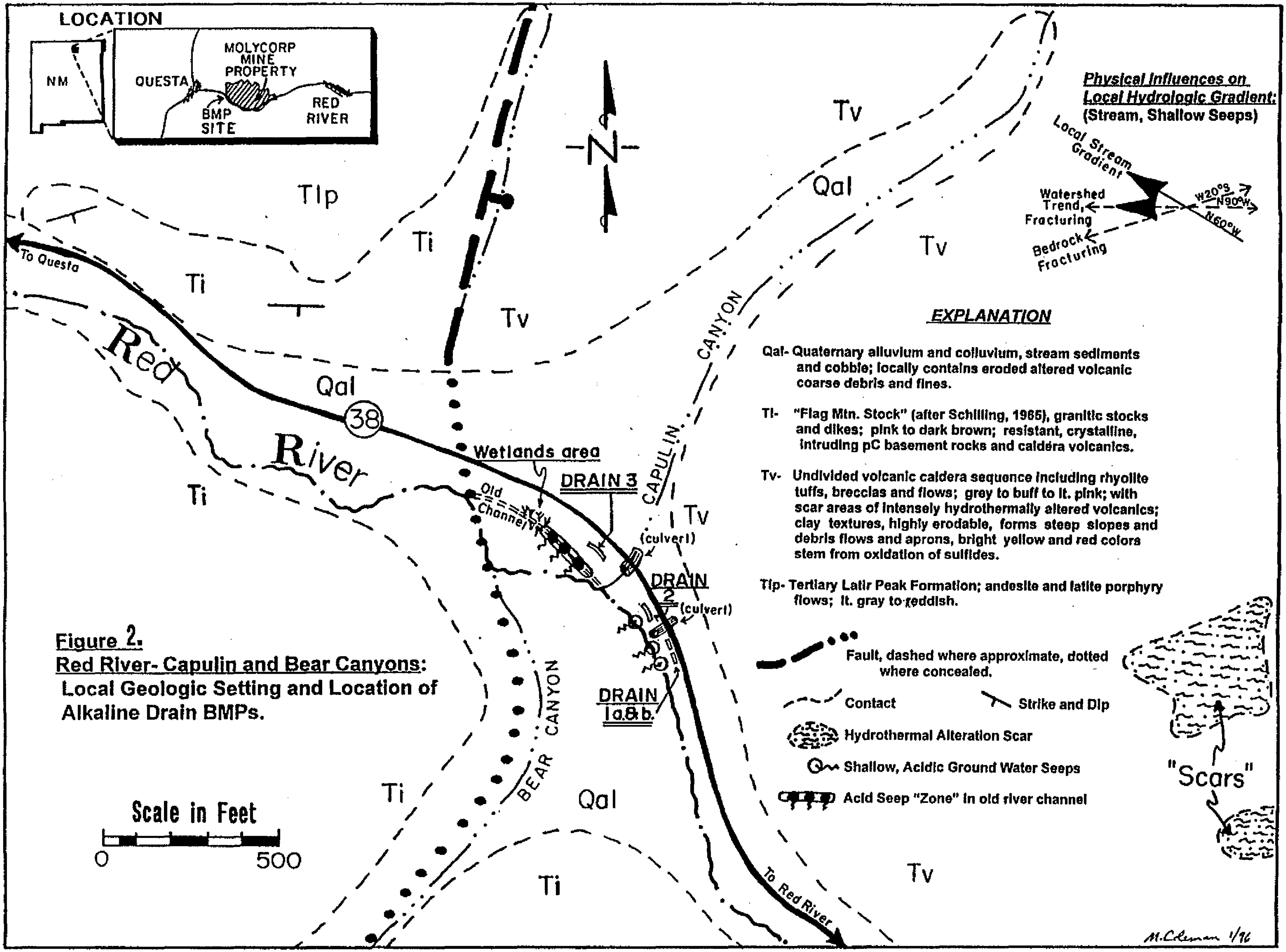
When air and water come into contact with either the widespread mine waste rock piles, the walls of the open pit mine or the exposed sulphide-rich erosional scars, the result can be generation of acid and mobilization of a suite of metals. When acidic water is introduced to soils or bedrock, it may leach additional available metals and emerge under or along the river as acidic, metal-loaded springs or seeps.

The NMED-SWQB project identified a number of seep source areas, generally along the north bank of the river, which are steadily delivering acidic water and heavy metals to the stream. Sampling reveals pH in the range of 3.0 to 4.1, and conductivity ranges from 1100 to 2400 umhos/cm. Analysis for heavy metals and water chemistry reveals a suite of dissolved and suspended metals, including Al, Cd, Co, Cu, Fe, Mn, Mo, Ni and Zn, at levels which exceed state and federal ground water quality standards.

The effort continues to better understand the relative contribution of polluted waters from the scar areas vs. the mining operations. Fingerprinting the acid waters is not a simple matter. Current analyses suggest direct runoff from mine waste contains greater sulfate, Al, Be, Mn, Zn, Cu, and Cd than waters from scar areas. A comparison of water chemistry of seeps downgradient of Molycorp's property, with those located upstream, shows a 3X increase of Al, Be, Cu, and Mn in the seeps below the mine and waste dumps area.

BMP implementation

On October 31 thru November 2, 1995, NMED-SWQB staff members Michael Coleman, Peter Monahan, Dennis Slifer, and Delbert Trujillo worked in tandem with Molycorp Questa Mine personnel, crews from the State Highway and Transportation Department, and the Questa Ranger District of the Carson National Forest in the installation of a BMP passive technology designed to improve the chemistry of the shallow ground water seeps.



EXPLANATION

Qal- Quaternary alluvium and colluvium, stream sediments and cobble; locally contains eroded altered volcanic coarse debris and fines.

Ti- "Flag Mtn. Stock" (after Schilling, 1965), granitic stocks and dikes; pink to dark brown; resistant, crystalline, intruding pC basement rocks and caldera volcanics.

Tv- Undivided volcanic caldera sequence including rhyolite tuffs, breccias and flows; grey to buff to lt. pink; with scar areas of intensely hydrothermally altered volcanics; clay textures, highly erodable, forms steep slopes and debris flows and aprons, bright yellow and red colors stem from oxidation of sulfides.

Tlp- Tertiary Latir Peak Formation; andesite and latite porphyry flows; lt. gray to reddish.

Fault, dashed where approximate, dotted where concealed.

Contact

Strike and Dip

Hydrothermal Alteration Scar

Shallow, Acidic Ground Water Seeps

Acid Seep "Zone" in old river channel

Figure 2.
Red River- Capulin and Bear Canyons: Local Geologic Setting and Location of Alkaline Drain BMPs.

The passive technology employed is known as **Anoxic Alkaline Drain Treatment** (AADTs). It was developed in the coal fields of the Appalachian and Atlantic Coast states to address acid waters escaping from abandoned or active coal mines and their pyrite-rich waste piles. The technology has previously been applied by NMED to only one other site in New Mexico, also within the Red River watershed. The treatment system is designed such that acidic waters low in dissolved oxygen will be intercepted by a buried trench filled with limestone (high alkaline grade, 80% calcium carbonate content) under continued anoxic (lacking oxygen) conditions. In theory, the seep water's pH will be raised from strongly acidic to less acidic conditions (a complete change to neutral or basic conditions is unlikely). Bicarbonate ions may be added to the water's chemistry. A significant portion of the dissolved or suspended metals should precipitate out uponcontact with carbonate rock and bicarbonate solutions in the trench, preventing the metals from being introduced into the Red River. In the long term, a downstream recovery of water quality and biological habitat is highly desirable.

NMED staff designed, coordinated and documented the BMP effort and will continue monitoring the seep areas. The installation involved a voluntary effort by Molycorp and the State Highway Department digging long, deep trenches along Highway 38, approximately two miles east of Questa. The trenches were placed on the northeast side of the river, adjacent to a particularly impacted active seepage zone near the Capulin Canyon tributary. The trenches are located on the highway road shoulder, ten to twelve feet above the level of the Red River. While it is an ideal site to attempt the BMP due to the presence of the active seeps, the logistics in the selected area were less than perfect. The available working area is only a few yards wide, making access difficult for the heavy equipment. Buried power and gas transmission lines occupy part of the areas originally intended for the BMP trenches.

Two distinct versions of acid seeps are present in the Capulin area. One style is referred to as "point seeps", where investigators identified individual discolored seep sites with small algae-filled pools along the rocky stream shoreline. The other form is a "seep front" which involves seepage accumulating within an abandoned Red River channel segment. The channel floor is iron oxide stained and saturated with acidic water but a discrete flowing seep source is difficult to identify. In this demonstration three trenches were situated immediately uphill, less than thirty feet from the point seeps (Figure 3). An alkaline trench was positioned eighteen feet from the channel seep front's eastern (upstream) end, but logistics prevented construction along that seep's western (downstream) reach, a distance of approximately 150'.

The trenches were dug to depths of 13-15 feet, into moderately consolidated streambank sediments. The trench lengths varied from 25' to 70' long. A total of 170 linear feet of trenches, in four segments were completed (Figure 3) along the 400'+ zone along the river which contains the seep areas. The trenches were dug as deep as possible while maintaining wall stability. When ground water was encountered, it was sampled and tested (analyses are pending). We could confirm that the same acidic conditions existed in ground water as those seen in the adjacent streamside or channel seeps. The trenches were partially filled with limestone cobble (2" to 6", rounded) delivered from near Tijeras, Bernalillo County (provided by Molycorp). A 20 mil thick polyethylene plastic sheet was secured over the limestone and a 2'-3' layer of bentonitic claystone (from near Antonito, Colorado) was placed on top of the plastic. Together, the plastic and clay form a cap over the limestone, aiding the acid/carbonate reaction in an anoxic environment. The trenches were backfilled with a clean fill dirt, surface graded, seeded and covered with a chopped straw mulch. The site presently gives no surface indication of the deep rock-filled trenches which underlie the area.

The channel seep infiltrates into sandy materials on its western (downstream) end. A small stand of acid tolerant wetlands vegetation (grasses, sedges and some woody shrubs) is established there. A future stage of the BMP installation may be further enhancement of the wetland area to assist the alkaline drains in finishing the pollution prevention process.

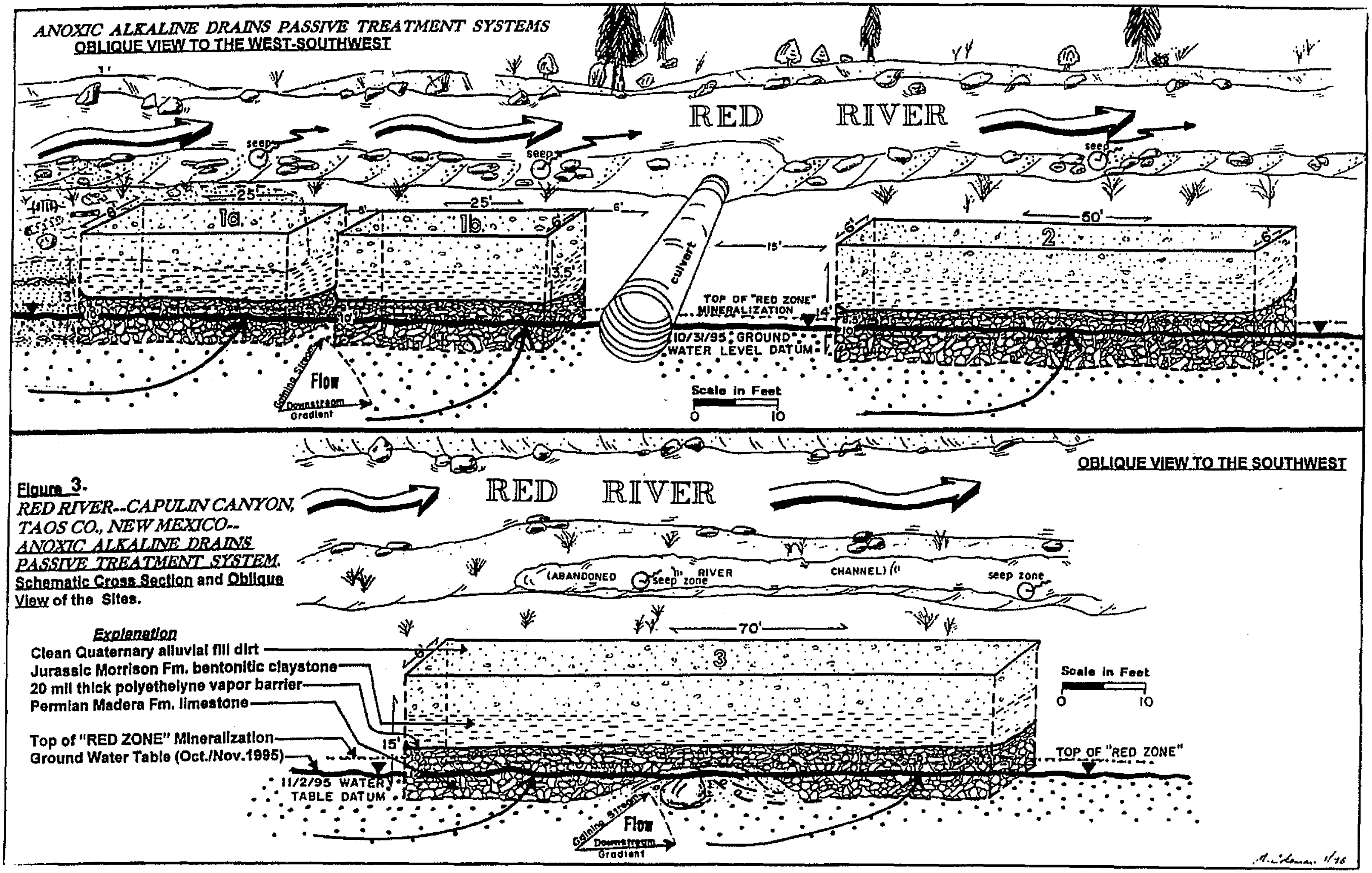


Figure 3. *RED RIVER--CAPULIN CANYON, TAOS CO., NEW MEXICO-- ANOXIC ALKALINE DRAINS PASSIVE TREATMENT SYSTEM.* **Schematic Cross Section and Oblique View of the Sites.**

ANOXIC ALKALINE DRAINS PASSIVE TREATMENT SYSTEMS

OBLIQUE VIEW TO THE WEST-SOUTHWEST

OBLIQUE VIEW TO THE SOUTHWEST

the Red River watershed will require active participation of the mining interests and equal attention to the vast areas of hydrothermal outcrops, administered by the Forest Service. This demonstration project and the principles behind it (if they prove some measure of success) may have widespread application adjacent to the active or abandoned mine sites elsewhere in the Red River watershed or in other areas of New Mexico where acid drainage from either mine sites or geological sources has become a serious water pollution problem. Built in series, with natural or constructed wetlands included in the overall design, this technology has certainly proven its effectiveness in other settings (Turner and McCoy, 1990; Nairn and others, 1992). The NMED Surface Water Quality Bureau and US Environmental Protection Agency are seeking additional demonstration sites and are hopeful of applying the Anoxic Alkaline Drain Treatment System technology in future water pollution prevention projects.

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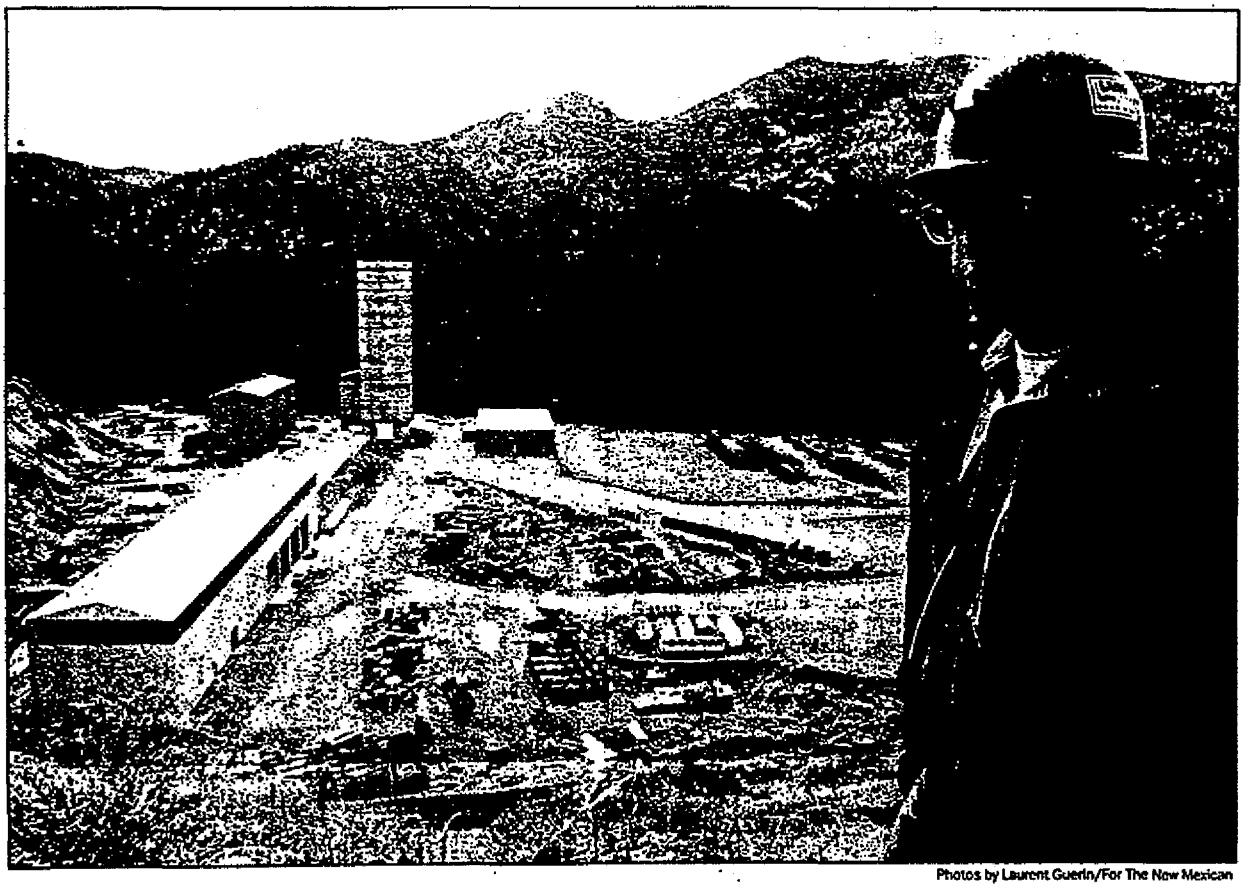
APPENDIX I

News media articles about Red River and Molycorp from the time period of this project (1994-1995).

11/12/94
The New Mexican

Questa mine might re-open



Photos by Laurent Guerin/For The New Mexican

David Shoemaker manages the Molycorp molybdenum mine at Questa, which has been maintained by a skeleton crew since it closed nearly two years ago. Shoemaker said Molycorp used to be Taos County's largest employer.

Action could create 225 jobs

By FRANCESCA CLINE
For The New Mexican

QUESTA — Officials at the Molycorp molybdenum mine, closed almost two years ago because of a worldwide drop in the price of the metal, say the mine could re-open next year because the price is rebounding.

Production at the mine would mean hiring 225 employees — the minimum needed to run the operation in northern Taos County, mine manager David Shoemaker said.

"I hope we would have some idea about production in the next six months," he said.

The price of molybdenum oxide, used to harden steel, has almost tripled since the mine shut its doors in 1992.

"It's been steadily going up all year but it just took off like a skyrocket in the past month," said Shoemaker, who has worked at the Questa Mine for 21 years. "There's some real hope here."

A skeleton crew has been employed at the mine since it closed.

"All the equipment's here," Shoemaker said.

According to *Metals Weekly*, Shoemaker said, as of last Monday molybdenum oxide had risen to $6.45 per pound. When the plant closed in 1992, the price was about $2 per pound.

Shoemaker said the plant needs to get at least $2.60 per pound to break even.

"As late as February of 1993 the price was below two dollars," Shoemaker said. "In August of this year the price was $3.50. The curve is going straight up."

Molycorp Inc., a subsidiary of the Los Angeles-based Unocal Corp., was Taos County's largest employer, at one time employing 850 workers, Shoemaker said.

In 1992 Molycorp employed 225 career miners and other staff on an $8 million payroll.

They produced 190 million pounds of molybdenum at the Questa mine in 1991.

According to Molycorp, the mine paid about $1 million a year in state and local taxes including property, process, severance and gross receipts taxes.

When the mine closed, it caused economic hardships for Questa, a village of 1,200 people about 20 miles north of Taos.

Molycorp also made unsuccessful attempts to sell the mining operation in order to recoup some of its losses.

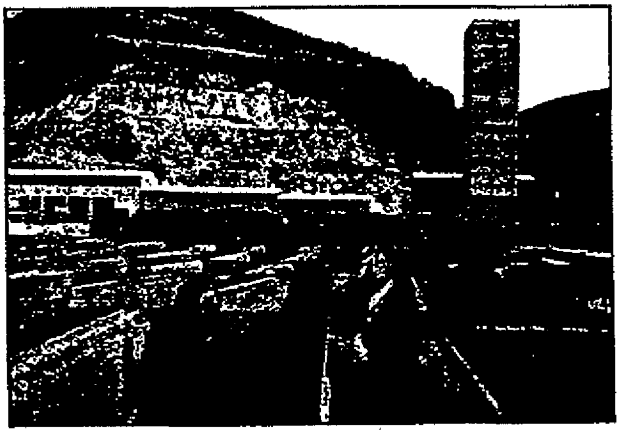
With the price of molybdenum oxide increasing, Shoemaker said the company is approaching steel companies for long-term commitments before operating the mine again.

"We are actively looking for possible customers," Shoemaker said. "We need to procure some sales. We have to see where this market will go and see if steel companies will make long-term contracts."

Shoemaker said reasons for the earlier price drop included an oversupply, an economic recession and the collapse of the former Soviet Union, which forced all metal prices down.

"What's encouraging is we're coming out of a recession," Shoemaker said. "Consumption is going up worldwide."

Due to price fluctuations, the mine had closed in 1986 and re-opened in the summer of 1989 before closing again two years ago.



Cars for carrying ore sit near the main shaft at the mine, where officials say equipment is ready if Molycorp resumes production.

E.D. MEETING AFFECTS FUTURE

The Environment Department of the State of New Mexico will be sponsoring a public meeting this Wednesday, December 7, at 7 p.m., in the Red River Town Hall.

The purpose of the meeting will be to establish and prioritize environmental issues as well as determining management goals for the area known as the Red River Watershed. All citizens who reside and/or do business in the Red River Valley, Wheeler Peak, Questa and Cabresto Canyon are urged to attend.

The Red River Miner contacted Jim Platt, Bureau Chief of the Surface Water Quality Department for the State of New Mexico. The interview was conducted by phone on Tuesday, November 29.

No stranger to the Red River, Jim has been fishing and hiking the area since the 1950's.

****

Miner: What is the goal of this Red River Watershed Association?

Jim: Let me give you just a little background first. The Red River Watershed has been studied by a large number of entities for a long time. EPA (Environmental Protection Administration) and its predecessor agency have done at least three different investigations up there, Bureau of Land Management and USGS (United States Geological Survey) have done a number of investigations. The Environment Department, or its predecessor, New Mexico Environmental Improvement Department have done a number. There are a number of concerned citizens who have come to us at one time or another and basically confirmed the results of all these investigations: Water quality in the Red River and some of its tributaries is going downhill, becoming less beneficial, less useful than what it has been in the past.

There's a number of interests within the Watershed who all, I think, have a common goal in wanting to see what is possible, what can be done to start addressing some of those concerns.

What the Environment Department is trying to do . and something that we've successfully done in other Watersheds in New Mexico (and, frankly, we're working on a big cooperative effort in the Southwest corner of the state with the State of Arizona, as well), is to try to get all the affected and/or interested parties to these water quality concerns to sit down at one time (and actually repetedly is how it will turn out), and start looking at the entire Watershed to identify the things that people see are problems and then to start prioritizing those problems in an attempt to actually get some on-ground remediation started.

Now, the way that we've tried to put this together is that the Environment Department will help facilitate the development of this, but we're not going to run it. We're not there to tell people what to do or, even for that matter, how to do it. We're there to lend technical expertise; to explain the technical concerns that we see up there; to make sure that people are going to sit down and discuss this thing. Then, we will back out of it, from a leadership role, and just work with individuals and work with concerned citizens up there to see what can be done.

By its very nature, we want this to be as inclusive as possible. We want to hear all sides of all concerns, and we want everybody, especially including all the economic interests in the Watershed, to sit down and help look at the problems and come up with solutions for them.

Miner: Sounds like a positive (and ambitious) step.

Jim: I'll be honest with you, when we first started this thing some time ago, I was a little leery. I mean, I came out of the Army. I kind of liked the command control situation. In one sense, that's a lot easier to do. But it doesn't get the job done and it doesn't include the people who have the largest stake in this entire thing.

There's some amazing talent in the Red River Watershed, just as we're finding in a number of other places. You've got Forest Service, BLM, private land owners, the two municipalities that are there. There are people who have lived up there for forty, fifty, sixty, eighty years. They know what is going on. They know some of the mechanisms that will work and they are going to be able to tell me that some we have used elsewhere aren't going to work there.

You've got MolyCorp right smack dab in the middle of it. I've worked for a long time with Moly Corp, sometimes as a regulator, sometimes as a cooperator. I think they have some amazing talent that can be brought to bear on this. I happen to know that there are people up there who sincerely want to get on top of this.

So, I think that what we're going to try to do, as I said, is sit down through a few meetings and see if we can facilitate this, see if we can get this program working and then, as I said, we can step back and work to help the people identify concerns and fix the concerns that they come up with.

Miner: What authority will the Watershed Association have?

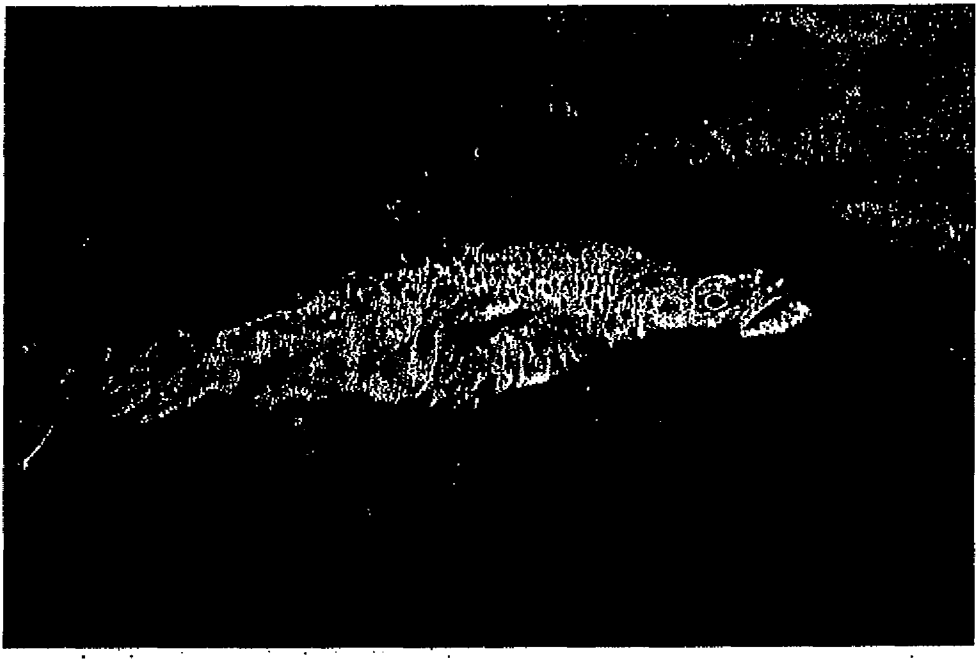
Jim: That's an interesting one. I think clearly that's going to depend on how it is ultimately formed. What we've done in the past is that we've intentionally (and everybody has actually asked for this) kept it pretty loose. They can certainly come in, for example, under the auspices of a soil and water conservation district, who clearly are a sub-state governmental agency that has got certain authorities. They could come back in under the auspices of the various municipalities so that they would literally have, if the municipalities wanted to go this way, zoning capabilities. In the past, what we've found is that people really haven't wanted to avail themselves of that- they just wanted to be concerned individuals working together on a cooperative basis. Not hammering on anyone, not forcing anyone, but literally working through a consensus-type of approach to, as I said, address areas of mutual concern.

*****

Don't Miss This Meeting!

The Red

Story and photos by **CRAIG MARTIN**
For The New Mexican



A brown trout comes to the surface after taking a fly.

Above the confluence of the Red River and the Rio Grande is a narrow tongue of rock, a secluded perch from which to study the rivers. When the sun dips behind the towering walls, the picture is in black and white: foaming water and black boulders. The noise is deafening as the sound of the water fills the canyon. Each river has a distinct sound: a throaty roar from the wide Rio Grande and a low rumble from the smaller Red.

The Red River is an improbable place for an important trout fishery. The confluence of the rivers lies deep within the lava walls of an 800-foot gorge. What sets the Red apart is its tumbling flow and clean gravel bottom, which make the smaller stream an ideal spawning ground for big brown trout and the cutthroat-rainbow hybrids that spend the better part of their lives in the waters of the Rio Grande.

Fifteen years ago, the Red River had a reputation throughout the West as a producer of big fish, but the number and size of the fish dropped dramatically in the early 1980s. The decline was coincident with the boom in molybdenum mining upstream but recently, the Red River has regained a bit of its former glory.

Taylor Streit, a longtime angling guide living in Taos, has seen the river's changing conditions.

"I remember when the Red River ran clear," he says, referring to the blue-gray cast the water has these days.

Streit sees steady improvement in the river.

"Each year it gets a little better," he says. "Right now it's good, but most people don't remember that it used to be fantastic."

Streit says trout in the river once averaged 16 inches. Now anglers will find many stocked rainbows in the usual 9-inch variety, and a few browns and cutbows. A 16-inch fish is considered large for the river.

The Red River begins as a mountain stream in the high country behind Wheeler Peak. Along its 40-mile course, the river cascades through mountain canyons, past the Red River Fish Hatchery a couple of miles below Questa, and then down to the Rio Grande.

The lower Red runs between rusty-brown walls from the hatchery to the confluence. The four-mile stretch has excellent holding water for trout. Thousands of boulders sit in midstream, creating currents that scour out a series of deep pools linked like a string of pearls. If the trout disappeared, the canyon would still be a wonderful place to explore.

Much of the flow of the Red pours from large springs within the gorge itself. The springs maintain winter water temperatures that are consistently higher than other rivers.

"It's where I go to fish when a cold snap comes in," Streit said. "A couple years ago, a client talked me into hitting the Red when the air was about 10 degrees. I mean, it was ridiculously cold. When we got there, mayflies were all over the water and we caught fish all day."

What makes fall and winter fishing in the Red River particularly attractive is the presence of spawning trout. From late September through November, brown trout move into the river to seek gravel beds to lay eggs.

"Most of the browns go way up near the hatchery to spawn," Streit said. "They pass through the entire stretch to get there, then return downstream to the river. You can find a few almost anywhere."

About the time the browns are done, rainbows and cutbows move from the Rio Grande into the Red to spawn. Streit says most of the big spawners of

Please see **RED**, Page C-2.

The New Mexican 11/30/95

Laurent Guerin/For The New Mexican

TAKING IT TO COURT: Standing between the Red River and a pile of waste from the Molycorp mine east of Questa, Roberto Vigil discusses the lawsuit filed Friday against the mine by Amigos Bravos, of which Vigil is a board member, and New Mexico Citizens for Clean Air and Water. The suit in U.S. District Court charges the Molycorp molybdenum mine with violating the Clean Water Act. Molycorp's manager, David Shoemaker, said the lawsuit has no merit and that Mother Nature — not the mine — contaminated the Red River.

The New Mexican 12/1/95

Photos by Laurent Guerin/For The New Mexican

State geologist Michael Coleman takes a reading for acidity where metals such as iron and manganese are seeping into the Red River.

Trenches catch acidic metals

By CATHERINE WALSH
For The New Mexican

QUESTA — Citing a desire to be "a good neighbor," Molycorp Inc. has teamed up with the state Environment Department and others in an effort to stop contaminated water from seeping into the Red River.

The mining company used its giant backhoe to dig four drainage trenches along the northern bank of the river near Capulin Canyon last month, said Dave Shoemaker, manager of Molycorp's molybdenum mine.

The company also has purchased several tons of limestone that was put into the trenches to leach out acidic fluids seeping into the river.

These limestone trenches were dug 13 to 15 feet deep, at or below the groundwater table. The trenches are part of a new technology that "neutralizes" water carrying acidic metals such as calcium and aluminum.

As water seeps through the limestone toward the river, the metals "drop out," Shoemaker said.

He said Molycorp's actions weren't motivated by accusations the company has turned the Red River into a dead river.

"We feel we don't have an impact on the river," he said. "We're controlling natural drainage (from the mine) and any problems we have are caught by interceptive barriers."

An environmental group in Taos said it holds Molycorp responsible for much of the pollu-

Please see **RIVER**, Page A-3

Test strips measure acidity at a seepage spot. Green algaes are not natural to the Red River and their presence is due to the high content of metals such as iron and manganese. The white deposit is calcium, aluminum and silica from the river fixed and crystallized by the metals of the seepage.

The New Mexican 11/21/95

AMIGOS BRAVOS
FRIENDS OF THE WILD RIVERS

MONTHLY BULLETIN
October 1995

Amigos Bravos Files Sixty-day Notice of Intent to Sue the Molycorp Molybdenum Mine (UNOCAL)

As of September 19th, 1995, the Western Environmental Law Center, on behalf of Amigos Bravos and The New Mexico Citizens for Clean Air and Water sent a sixty day notice of intent to sue the Molycorp mine (UNOCAL). We sent a follow up letter a few days later requesting a meeting with UNOCAL representatives. The letter stated that we are open to negotiations which result in a court ordered consent decree.

Amigos Bravos has long suspected that Molycorp is causing seeps to release pollutants into the Red River and now, after extensive research we can prove it!

The Molycorp mine has been polluting the Red River since the mine's inception decades ago. The mine has been on record and fined for point source pollution (involving broken tailings pipes) numerous times. In the early seventies, shortly after the mine significantly extended its activities and began using the open pit, water in the river just below the mine began to turn a milky blue-ish white due to an aluminum hydroxide (gibbsite) deposit which now coats the river floor. Acid leachate occurs naturally in the surrounding geology, however, common sense recognizes that there is now additional leaching into the river as a result of the massive disturbance caused by the mine. The river stones and crevices are so coated by the gibbsite that no macroinvertebrates — small bugs which fish feed on — can live there. The result is that the Red River — once considered a blue ribbon fishery — is biologically dead for an eight mile stretch between the mine and the confluence of the Red River with the Rio Grande.

The degraded condition of the Red River has been documented by the New Mexico Environment Department and other federal and state agencies for over a decade. Toxic levels of metals including Aluminum, Copper, Zinc, Lead, Cadmium, and Silver have been detected in samples from a 20 mile reach of the Red River between its confluence with Placer Creek to where it enters the Rio Grande. Other problems noted in the river include turbidity, pathogens, siltation and organic chemicals; the source of these problems has been traced primarily to runoff and seepage from mill tailings and mine tailings, as well as to overgrazing, leaking fuel tanks, domestic septic systems, and forest road construction.

The Molycorp molybdenum mine is the principal actor in the mining and milling activities which are implicated in the metals contamination of the river. However, several very small, historical abandoned mines contribute to the problem. Additionally, natural sloughing and leaching of acidic soils has been identified as a potential source of some of the problems detected in the river. Uncertainty as to the source or sources of the metals contamination has been partially responsible for the failure of the state to take action against Molycorp to force reclamation activies to restore the river to health. Whereas the state does have the authority to enter into cleanup activities and subsequently recover costs against parties found to be responsible for the contamination of the Red River, state funding for such a cleanup was scuttled by the legislature in the last legislative session. The newly elected governor, a business man with no prior experience as an elected official, vetoed any increase in government spending and placed a hiring freeze on additional government employees even in the case of situations that will provide enormous returns for long term public health and safety. Thus, the surest pathway to restoring the river to health is to quantify the degree of Molycorp's responsibility for the river's degraded condition, and with this information to be prepared take legal action, if absolutely necessary, to ensure that the company initiates and brings to completion the reclamation of the Red River.

Amigos Bravos was formed in 1988 specifically to fight a Molycorp proposal to build an additional tailings pond. Amigos Bravos was the lead plaintiff in a suit filed against the BLM for giving Molycorp permission to build the pond. Under threat of that suit, the National Director of the BLM rescinded the State Director's decision and the tailings pond was never built. In spite of seven years of direct dialogue with Molycorp representatives, community organizing and outcry, and pressure exerted through the media, we have been unable to convince the mine to clean up the mess it began decades ago, continued to create after our initial suit, and left behind when the mine closed a few years ago. Pollution from the massive disturbance caused by the mine continues today unmitigated.

In the winter of 1995 Amigos Bravos began a dedicated search for funds necessary to hire the science needed to determine the degree of Molycorp's responsibility for the river's degraded condition. By mid-July we had a first installment of our projected funding needs, and contracted the firm of Souder, Miller and Associates, an environmental consulting and engineering firm based in Santa Fe, with extensive experience working with and for small communities in northern New Mexico . The Western Environmental Law Center made calls to the New Mexico Environmental Law Center, the Land and Water Fund of the Rockies, and the Atlantic States Legal Foundation in New York City, all of whom have been involved in researching potential litigation in the past. WELC asked each of the law firms if they were currently pursuing research or litigation on behalf of any other parties in relation to the Molymine and the Red River in Questa. The answer from each firm was negative. Having ascertained that the playing field was clear, and that we would not be duplicating efforts or preempting legal work already in motion — by any other individual, group of individuals, organization, or law firm — we proceeded.

A number of Questa residents are dues paying members of Amigos Bravos. Roberto Vigil, an artist and long time environmental activist in relation to the Molymine and its impact on the community of Questa, is a member of the Amigos Bravos board of directors and is participating closely with the executive staff in the decision-making processes in regard to the possible suit

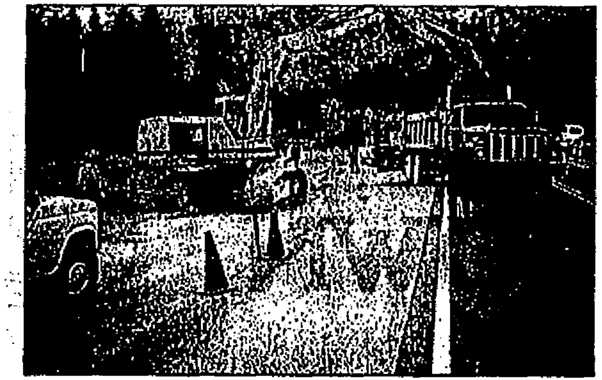
continued on page 2

Environment Dept:

Environment Department Protects Red River

New Mexico Environment Department (NMED) staff members **Michael Coleman, Dennis Slifer** and **Peter Monahan** initiated a cooperative plan involving NMED, the Molycorp Questa Mine, the State Highway and Transportation Department (NMSHTD), the Questa Ranger District/ Carson National Forest and the U.S. EPA.

"The project involved the implementation of a relatively new technology: anoxic alkaline trenches acting as a passive treatment system to intercept and arrest acidic, metal-loaded groundwater or acid mine drainage," said **Michael Coleman** of NMED. "The project is situated along the Red River, between Questa and the town of Red River, Taos County."



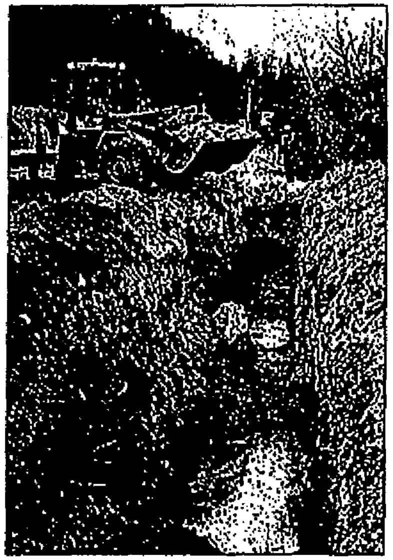
Molycorp and NM Highway Dept. heavy equipment installed trenches along Highway 38 adjacent to Red River. Once the trenches are filled with limestone and clay, they intercept and neutralize acidic, metal-loaded ground water seeping into the river. The process is known as "anoxic alkaline drain passive treatment."

"The impacted area was identified during our current EPA Grant project (Red River Groundwater Investigation, FY-92-A, 319[h])," said **Dennis Slifer** of NMED. "The objectives of the Grant project are to determine groundwater and aquifer characteristics in order to identify—and ultimately eliminate—impairment of both the aquifer and the designated uses of the river. The alkaline trenches represent the Best Management Practice (BMP) which was selected to improve obvious water quality impairments: the perennial, steady state seepage of acid waters into the river, effects upon macroinvertibrate and fish populations and the overall negative impact on water quality."

"Trenches 25' to 70' long, 5' to 8' wide, and 13' to 15' deep were dug into the highway shoulder, adjacent to the north bank of the river," explained **Peter Monahan** of NMED. "Four segments, totaling 170 linear feet, were placed directly up grade from active seep areas, presently delivering a steady pH 3.4 to the stream. The trenches were half filled with limestone cobble, and a polyethylene mat vapor barrier was placed over the carbonates. The system is sealed by an overlying layer of bentonite clay and filled back to grade with clean soil. The areas were then leveled, seeded and covered with a chopped straw mulch."

"Molycorp covered the cost of the raw materials and provided a large track hoe and operator to dig the deep trenches," added **Ed Kelley**, Water and Waste Management Division Director at NMED. "The Highway Department assigned a full crew with a smaller backhoe, a loader, dump truck and traffic control. The Forest Service expedited all necessary NEPA clearance. The Environment Department costs were limited to staff time for planning and project oversite and a few minor supplies." Kelley is in charge of the division in which Coleman, Slifer and Monahan work.

photos by Dennis Slifer, NMED



As the trench is filled with limestone cobble, ground water accumulates. The water quality precisely matches streamside seeps.

"The project was a beautiful example of industry and State agencies working together in complete harmony towards a goal which could be of benefit to the entire state," said **Bill Williams**, Communications Director of NMED. "The demonstration project, if it proves to be successful, will have widespread application around abandoned or active mines or in natural geologic areas where acid rock drainage is occurring," added Williams.

The project was a collaboration of the U.S. EPA, whose grants fund the work of the NMED Surface Water Quality Bureau, Nonpoint Source Pollution Section; the New Mexico Highway and Transportation Department, whose supervisors, crews and heavy equipment made the project possible; and the Questa Ranger District - Carson National Forest who expedited the permit process.

NMED acquired over an hour and a half of video documenting the field operations and have plans to shoot additional scripted footage which will explain the watershed setting, BMP concept and expected results. NMED is planning to do a professional editing job with voiceover narration. NMED has a complete set of color slides and photos documenting the work. The NPS Section's newsletter, *Clearing the Waters*, is planning to feature the project in a future issue.

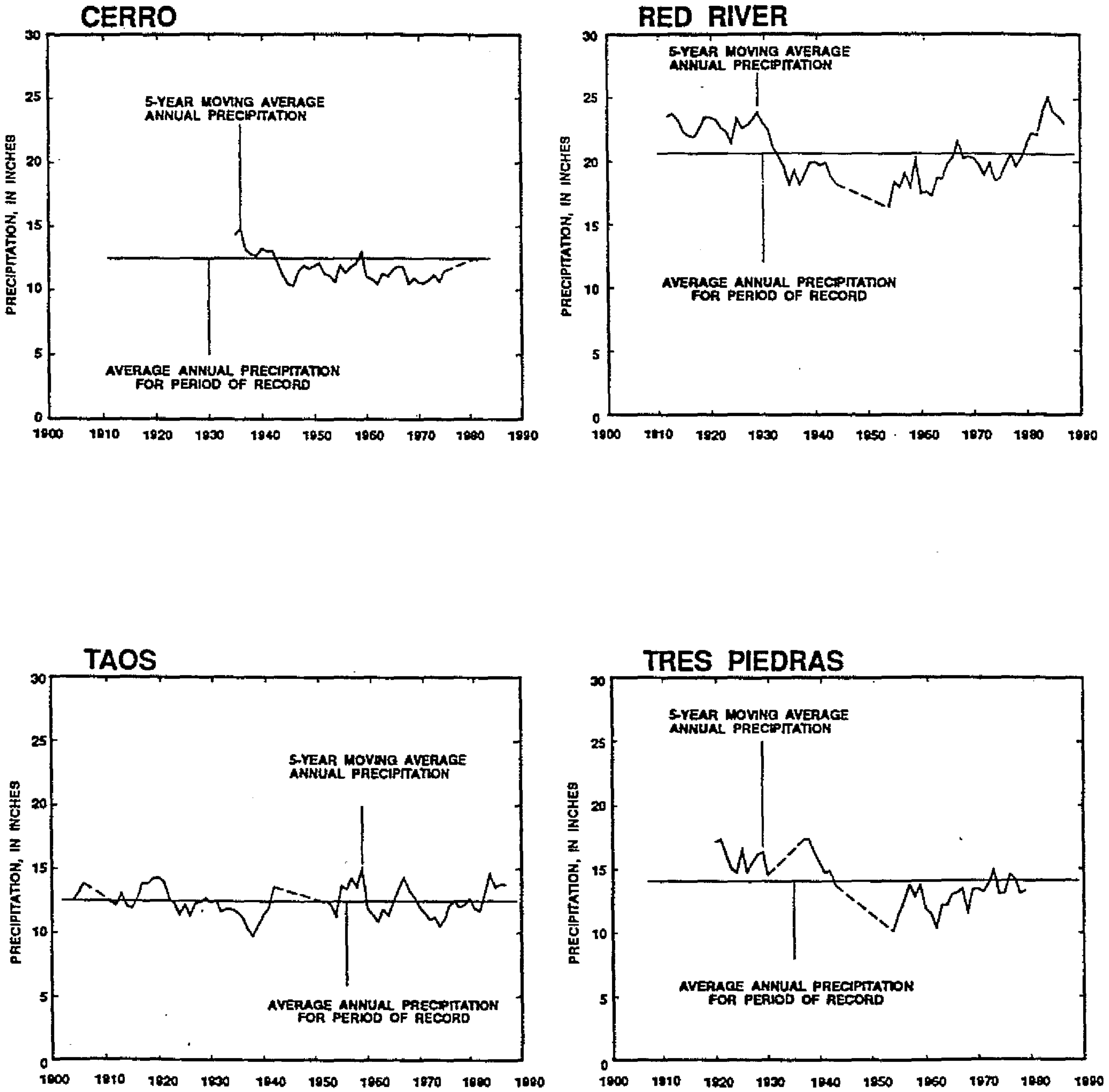
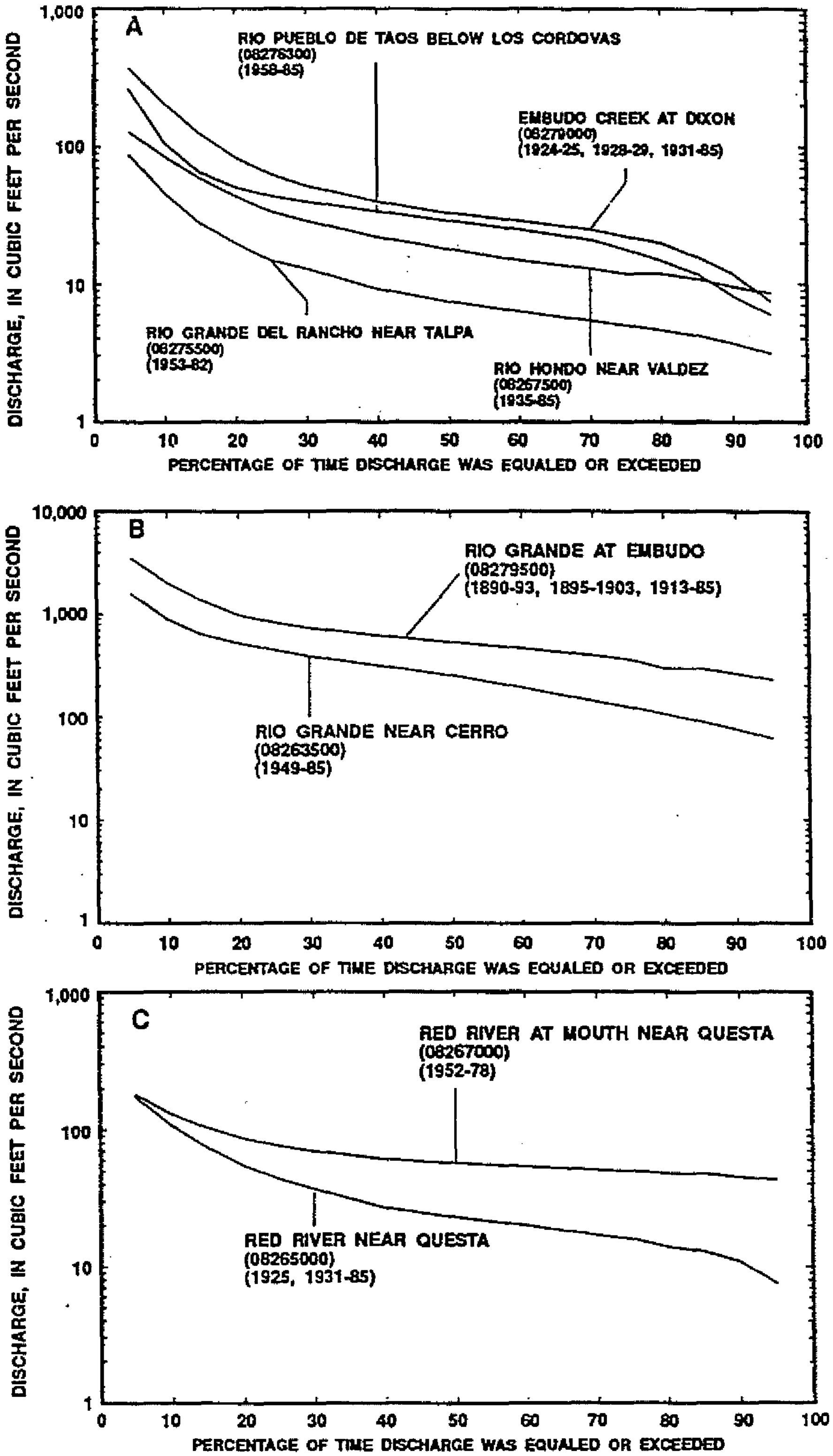


Figure 2.--Average annual precipitation for period of record and 5-year moving average of annual precipitation at Cerro, Red River, Taos, and Tres Piedras weather stations. Dashed lines indicate years of missing data.

Garrabrant, 1993



re 12.--Flow-duration curves for mean daily flows for (A) four tributaries of the Rio Grande; (B) the Rio Grande near Cerro and at Embudo; and (C) the Red River near Questa and at the mouth (data from Waltemeyer, 1989).

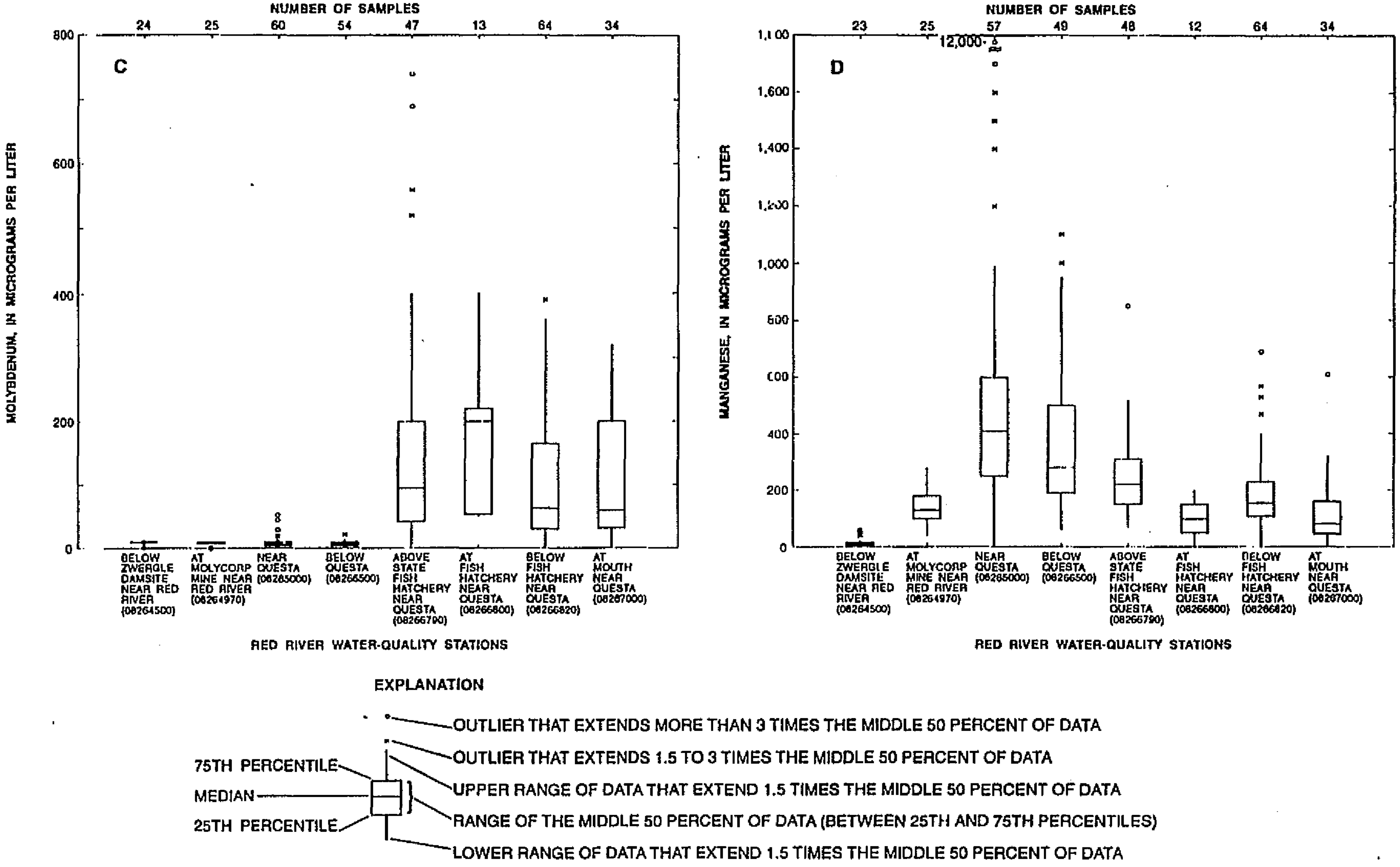


Figure 16.--Selected water-quality properties and constituents in the Red River: (A) specific conductance; (B) sulfate; (C) molybdenum; and (D) manganese--Concluded. See figure 14 for location of stations.

Garrabrant, 1993

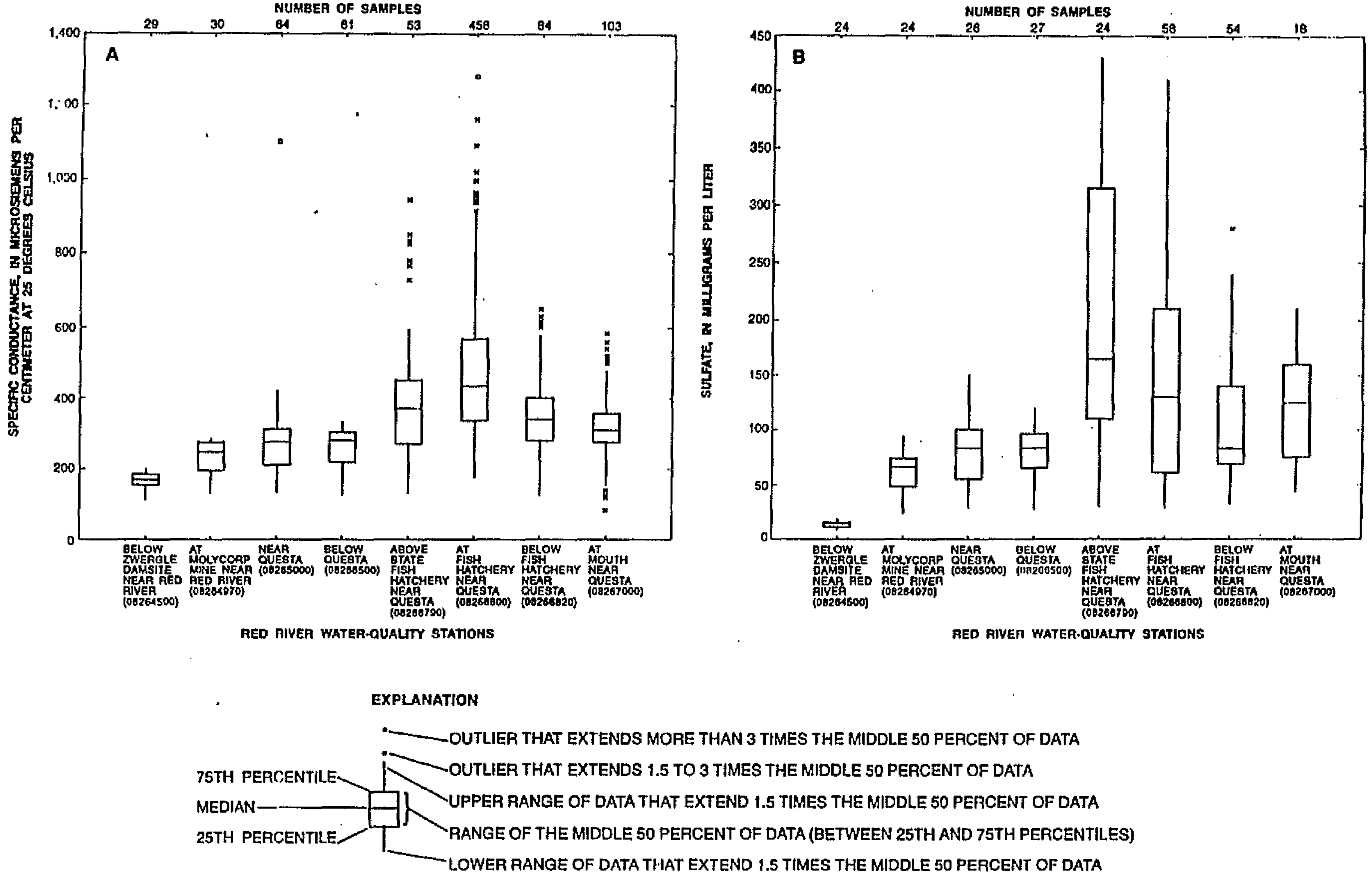


Figure 16.--Selected water-quality properties and constituents in the Red River: (A) specific conductance; (B) sulfate; (C) molybdenum; and (D) manganese. See figure 14 for location of stations.

Reclaim Red River

With the market price of molybdenum at around $4 a pound and going down, one is given cause to wonder if the Molycorp mine's promise of 250 jobs is a public relations ploy.

I am in favor of jobs for miners at Molycorp, and the surest way to crate those jobs is to require that Molycorp undertake the reclamation of the Red River.

Even a casual observer driving between Red River and Questa notices the strange milky blue color of the river below the mine. From beneath the disturbed slopes, pools of rust red acid mine drainage collect and make their way to the river.

As soon as those seeps come into contract with the river water, a chemical reaction precipitates an aluminum alloy which coats the entire floor of the river white. This creates a hostile environment for macroinvertebrates, whose populations are the gauge of a healthy river and provide food for trout.

There are not trout reproducing in the eight mile section of river below the Molycorp mine.

It is in Molycorp's financial interest to blame others, including environmentalists and even nature, for the problems the mine has created while promising prosperity at some future date in exchange for favors now.

What Molycorp could do, for everyone's benefit, is hire not just 250 people, but 500, or even a 1,000 workers to begin what will doubtlessly be the long and arduous task of restoring the Red River ecosystem for future generations.

Sawnie Morris
Director
Amigos Bravos:
Friends of the Wild Rivers
Santa Fe

The New Mexican
9/95

Here's how U.S. copper mines stack up

This is reprinted from the November 1995 issue of ChinoNews, the newsletter for Chino Mines Co.

What is the largest copper mine in the world? And where does Chino Mines Co. fit in? The answers can be found in the May 1995 Directory of Copper Mines and Plants published by the International Copper Study Group of Lisbon, Portugal. It lists virtually every copper mine in the world.

Following are the 20 largest copper producers in the world, ranked according to annual copper production.

If two companies might have the same annual production, they are listed alphabetically. The last number in each listing represents copper production capacity in pounds for 1994.

(Our new Candelaria mine is not listed. At a budgeted production of about 231 million pounds of copper next year, it is not among the 20 largest mines in the world.)

1. Chuquicamata.

Chile. Codelco. Open pit, established 1915. 1.3 billion.

2. La Escondida.

Chile. Consortium. Open pit, established 1991. 1.1 billion.

3. Phelps Dodge Morenci Inc.

USA. Phelps Dodge and Sumitomo. Open pit, established 1937. 900 million.

4. Norisk Nickel Operations.

Russia. Norisk Nickel. Underground/open pit, established in 1939 and 1948, respectively. 770 million.

5. Grasberg.

Indonesia. Freeport Copper. Open pit, established 1990. 704 million.

6. ElTeniente.

Chile. Codelco. Underground, established 1906. 682 million.

7. Bingham Canyon.

USA. Kennecott/RTZ. Open pit, established 1904. 660 million.

8. OkTedi.

Papua New Guinea. Ok Tedi Mining Ltd. Open pit, established 1987. 451 million.

9. Mount Isa.

Australia. Mount Isa Mines Ltd. Underground, established 1931. 418 million.

10. Dzezkazgan Complex.

Kazakhstan. Dzezkazgan Metallurgical Enterprise. Two open pits, three underground mines, established 1928, 1955, 1964. 396 million.

10. Poland Rudna.

Poland. KGHM Polska Miedz S.A. Underground, established 1974. 396 million.

12. San Manuel/Kalamazoo.

USA. Magma Copper Co. Underground/openpit, established 1956. 378 million.

13. HighlandValley.

Canada. HighlandValley Copper. Two open pits, established 1962, 1972. 363 million.

13. Ray Complex.

USA. ASARCO Inc. Open pit, established as underground mine in 1911. 363 million.

15. La Caridad

Mexico. Mexicana de Cobre. Open pit, established 1979. 362 million.

16. Chino Mines Co.

USA. Phelps Dodge/Heisei Minerals. Open pit, established 1911. 345 million.

17. Cuajone.

Peru. Southern Peru Copper Corp. Open pit, established 1977. 319 million.

18. Andina.

Chile. Codelco. Underground/open pit, established 1970 and 1983, respectively. 308 million.

19. Neves-Corvo Project.

Portugal. Sde. Mineira de Neves Corvo SA. Underground, established 1988. 308 million.

20. Sierrita/Twin Buttes.

USA. Cyprus Climax Metals Co. Open pit, established 1970. 297 million.

Molycorp does cleanup work at Questa

QUESTA (AP) -- Molycorp has dug four drainage trenches along the northern bank of the Red River near Capulin Canyon to stop contaminated water from seeping into the river.

Dave Shoemaker, manager of the Molycorp molybdenum mine, said the company also put several tons of limestone into the trenches in October to leach out acidic fluids and keep them from seeping into the river. As water drains through the limestone, the metals "drop out," he said.

A Taos environmental group has said it holds Molycorp responsible for much of the pollution in the Red River. But the group, Amigos Bravos, welcomed the company's "wonderful gesture" of digging the trenches.

"We hope it's a sign that they are moving forward to clean up the Red River and providing jobs to do it," said Sawnie Morris, Amigos Bravos co-director.

Shoemaker said Molycorp's actions weren't motivated by accusations that it is responsible for the river's pollution.

"We feel we don't have an impact on the river," he said. "We're controlling natural drainage (from the mine) and any problems we have are caught by interceptive barriers."

Of Mines and Miners

FCX purchases Freeport Copper for $25 million

Freeport-McMoRan Copper & Gold Inc. has purchased 100 percent of Freeport Copper Co. for $25 million from Freeport-McMoRan Inc. Freeport Copper is a partner in the Santa Cruz experimental in situ leaching project near Casa Grande.