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PROGRESS REPORT ON THE GEOLOGY, HYDROGEOLOGY, AND WATER QUALITY OF THE MINE AREA

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Progress Report on the Geology, Hydrogeology, And Water Quality of the Mine Area

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1.0 INTRODUCTION AND SUMMARY

1.1 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). The Mine Area lies north of the Red River and State Highway 38 which 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 study area has been defined as the ***Mine Area,*** which consists of extraction, processing, and rock-waste deposition activities. The significant features associated with the Mine Area are shown on Figure 2.

Mining for molybdenum began in the Questa area between 1916 to 1920. The nature of mining activities progressed form the original underground workings to open-pit operations (beginning in 1964-65), and back to the more recent underground mining (beginning in 1979-1983). Mine waste-rock dumps were emplaced during the 1970s and 1980s when the open pit was excavated. The mine went on temporary standby status in 1986 until economic conditions improve for the molybdenum market. Mine dewatering resumed in July 1994 in anticipation of potential reactivation of mining activities.

The Molycorp mining operations have been both extractive in nature (the Mine Area) and simultaneously depositional (the Mine Area waste-rock dumps and the Tailings Area). Large-scale extractive or depositional activities normally will have an impact on a natural environment. Molycorp has been both proactive and responsive to examination of the environmental impacts resulting from their activities. In the Mine Area, any adverse water-quality impacts are exacerbated, if not exceeded, by natural impacts (e.g.-acid runoff from hydrothermal scars). Water-quality data from several sources, including the Red River sewage treatment plant well, Hanson Creek, and Hot-N-Tot Creek indicate significant natural contributions to surface-water and ground-water quality degradation.

In 1989, Molycorp retained the services of South Pass Resources, Inc. (*SPRI*) to evaluate impacts of past and present Molycorp operations on ground-water and surface-water quality. The dominant environmental concerns are two-fold:

- What impacts, if any, have mining operations had on surface-water (Red River) or ground-water quality?
- What percentage of any surface-water or ground-water quality degradation is from natural (versus mining-related) sources?

These issues are under study by consultants currently retained by Molycorp (including SPRI, Vail Engineering, and Steffen Robertson & Kirsten). Previous studies by SPRI, Dames and Moore, Harding-Lawson, Water Resource Associates, Geocon, Vail and Associates, ENSR, and others have focused on definition of the geologic, hydrogeologic, water quality, and hydrologic characteristics in and about the Molycorp facilities. Of particular emphasis has been definition of those naturally-occurring physical and chemical parameters that control real or potential contaminant migration pathways and concentrations.

SPRI's most recent (Summer and Fall 1994) activities have involved the design, installation, and testing of 12 new monitor wells in the Mine Area. This report presents a detailed discussion of the results of the 1994 investigation, and of previous investigations, and an evaluation of recent geologic, hydrogeologic, and water-quality data.

1.2 SUMMARY OF FALL 1994 AND PREVIOUS INVESTIGATIONS

Beginning on July 11, 1994, SPRI overviewed the design, installation, and testing of 12 new monitor/extraction wells in the Mine Area. The purpose of this investigation was to:

- characterize the water quality of naturally occurring ground water and seeps and compare these data to seepage from mining activities; and
- characterize the geologic controls on fluid movement.

In addition, the drawdown associated with the cone of depression from dewatering of the mine is being monitored within the newly-installed wells. It will take a year or more of monitoring before drawdown rates can be quantified; some additional monitor wells may be required.

The wells that were installed during the 1994 investigation, and the details of their installation and testing, are summarized below. The locations of these wells and other wells installed in the Mine Area are shown on Figure 2.

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

A partial listing of the other monitor and extraction wells in the Mine Area that predate 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 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

2.0 GEOLOGY AND HYDROGEOLOGY

2.1 GENERAL GEOLOGIC SETTING

The major sources of geologic data for the Questa Mine area are Schilling (1956), Rehrig (1969), Lipman (1981), Bookstrom (1981), and numerous unpublished maps, cross-sections, and reports by Molycorp geologists. A common thread to all of 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. This structural zone is variously interpreted as part of a graben (Schilling, 1956); as a zone of intense faulting (called the Red River Structural Zone by Rehrig, 1969); and the southern part of the outer ring fracture zone that formed the outer wall of the Questa caldera (Lipmann, 1981; Bookstrom, 1981).

The development of the caldera and the associated volcanic and intrusive rocks was a late Oligocene to Middle Miocene event (27.2 to 22 million years before present) that was concurrent to and overlapped the regional rifting associated with the Rio Grande Rift System. The range-bounding high-angle fault along the west side of the Sangre de Cristo Mountains (about 5 miles west of the mine) is related to regional extension across the Rio Grande Rift and the uplift of the range in Mid-Tertiary time. At least the later movements along this range-front fault are younger than the caldera structure because the outer ring fracture zone is truncated by the range-front fault.

2.2 MINE AREA GEOLOGY AND HYDROGEOLOGY

Geology

The Mine Area is composed of Pre-Cambrian igneous, metasedimentary, metavolcanic, and other metamorphic rocks, overlain by a thick sequence of Tertiary ashflow tuffs and andesitic lava flows. These rock types have been intruded by granitic rocks, forming dikes, and elongated intrusions. Mineralized quartz veins in the Mine Aplite (i.e., finely crystalline granite) and in the adjacent intruded volcanics were formed during a late magmatic, post-caldera hydrothermal stage. The Mine Area is within a northeast- to east-trending structural rift zone that forms the south side of the Questa caldera. This structural rift zone contains numerous dikes and mineral veins. Fractures and fault discontinuities are widely varied, as illustrated on a geologic cross-section (Figure 3), and include:

- high-angle faults and joints;
- low-angle faults; and

- contact-zone fractures between different rock units.

The mined ore deposits consist of molybdenite-bearing quartz veins.

Hydrogeology

In the Mine Area, the most significant controls to fluid movement appear to be preferred channels within mud flows, location and degree of geologic discontinuities (faults, joints, fractures), man-made fluctuations of the water table north of the Red River, and hydraulic conductivity differences between mine waste-rock, bedrock, and valley-fill (mudflow or alluvium). Water-quality degradation of the Red River in the Mine Area has been found to be heavily controlled by natural processes and is influenced locally from byproducts of mining.

Hydrogeologic units include a basement (Pre-Cambrian) aquitard, overlain by volcanics and sedimentary rock aquifers, and/or valley-fill mudflow and alluvial valley-fill aquifers. Hydrothermal scar materials of low hydraulic conductivity are scattered over the area. Mine waste dumps contain perched aquifers.

The natural ground-water gradients are toward the Red River. Mine dewatering operations have created a cone of depression around the underground mine workings. The primary hydrologic linkage between up-gradient sources and the river is the fan delta deposits at the mouths of tributary canyons at Capulin Canyon and Sugar Shack South. The 12 monitor/extraction wells installed by SPRI in Fall 1994 were screened in fan delta and bedrock aquifers, and were constructed at sites near the mouths of tributary canyons to evaluate these linkages. Water-quality sampling and water-level measurements were made in cooperation with the New Mexico Environmental Improvement Department (EID) in November 1994.

In the Mine Area, low pH, high total dissolved solids (TDS), and high sulfate characterize the natural springs and seeps as well as surface water in drainages crossing hydrothermal scar areas. Analytical results of water quality sampling along and adjacent to the Red River indicates both natural and mine-related seepage affect the water quality of the Red River. Deep underground mine water has a slightly alkaline pH plus slightly elevated levels of TDS and sulfate.

Water in the unsaturated zone, water in the perched-water zones, and ground water move from sources to discharge points. Sources of this water are both natural and mine-related: infiltration, surface run-off, and seepage from natural springs and mine-constructed waste-rock piles. The discharge points consist of the deep underground mine, the Red River, and (via slurry line) the Tailings Area ponds. Water that arrives at the discharge points consists of natural acidic drainage mixed with varying amounts of waste-rock dump-related water.

Naturally acidic waters have been in transit through the same system, excluding seepage barriers, for thousands of years as is evident from limonite-cemented alluvial and mudflow deposits.

Perched water can form near the base of the waste-rock dumps. Perched water can also form in zones of fractured bedrock above the main water table and above clay intervals in the valley-fill. Bedrock seeps, such as the seeps at Cabin Springs near the river, may be from a perched bedrock zone.

Dewatering of the new underground mine (1979 to 1992 and resumed in July 1994) has created a cone of depression that appears to extend in some places to the Red River. The original cone of depression may have captured much of the natural and mine-related discharge. However, Capulin Canyon appears to lie outside the zone of influence of dewatering. Also, the Cabin Spring seepage (which may be perched) may not be impacted by the dewatering cone of depression.

The impact of the current mine dewatering on recharge of mine-related seepage to the Red River cannot be properly evaluated until after at least one year of data collection including monthly water-level measurements and quarterly water-quality analysis (similar to data collection of November 1994). Bladder pumps were used to collect water-quality samples at all of the mine monitor/extraction wells because (with some exception) the wells appear to be low yield (less than a few gallons per minute). The known exceptions are MMW-11 (bedrock well in a fracture zone), which pumped at a rate of more than 60 gpm, and MMW-10A (valley-fill well), which pumped at 140 gpm with 3 feet of drawdown. Because the existing extraction wells in the Mine Area tend to be low-yield wells, their capacity to control seepage by pumping is limited.

Appendices A and B contain more detailed discussions of the Mine Area geology and hydrogeology. Appendix C contains geologic logs for wells emplaced during SPRI's 1994 investigation. Appendix D contains data and discussions on water quality.

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.

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. [illegible]

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.

4.0 RECOMMENDED WORK

Based on SPRI's 1994 field and previous investigations, the geology and hydrogeology of the Mine Area and their relation to water quality and the Red River have been further defined. Any new monitor well placements will be based on pending geophysical work, plus continued sampling and water-level measurements.

4.1 SURFACE GEOPHYSICAL SURVEYS

Geophysical surveys would be useful for defining alluvial/bedrock contacts. Such information would then be utilized in selection of any future monitor well emplacements. Potential sites for limited geophysical activity could include:

- the delta at Capulin Canyon,
- Goathill Gulch (including its eastward continuation across the unnamed tributary: MMW-8 wells),
- the Sugar Shack South area, and
- the Cabin Springs area.

Geophysicists advocate the use of a series of east-west seismic refraction lines across the fan deltas. Fan delta deposits (valley-fill sediments) occur at the mouths of the tributary canyons and are an important link between up-valley surface drainage and bedrock aquifer discharge to seepage at the river. The configuration of the bedrock surface beneath the fill, particularly if there is more than one bedrock channel, and the variation in thickness of the fill and related changes in thickness of the saturated portion are important parameters in planning for additional monitor or extraction wells.

4.2 MONITOR AND EXTRACTION WELLS

SPRI recommends that monitor/extraction wells be sited in the following areas. Proposed locations are shown on Figure 10.

<u>Capulin Canyon</u>: Sumps at the toe of the Capulin waste-rock dump, the pumpback pond, and monitor wells MMW-2 and -3 are currently available to monitor recharge from natural and man-induced sources. A small diameter (2-inch) monitor well screened in valley-fill and located near the narrows in Capulin Canyon would be a

useful site for collecting water-quality data. This would allow some comparisons between upper canyon and mouth-of-canyon sources.

Sugar Shack South Waste-Rock Dump Area: A valley-fill well west of the road to MMW-11 and north of the powerline is recommended for construction to monitor ground-water flow toward Portal Springs. This well would help to better define flow direction and hydraulic gradient for the valley-fill aquifer at this site.

4.3 WATER-QUALITY MONITORING

SPRI recommends that water-quality measurements be performed quarterly using the QA/QC procedures and the equipment (inline filters and bladder pumps for minipurging) developed during the November 1994 sampling period. To facilitate statistical comparisons among samples and statistical discrimination among sources, the set of physical measurements, cations and anions included in the November 1994 work should be continued. To develop models of the chemical loading of surface water and ground water from various sources in the tributary canyons (natural seeps and springs, waste-rock dump sump water) and to the Red River (river seeps and selected river samples), water quality from these sources should be included in the quarterly program. Flow rates from these various sources should be estimated during each sampling period as input for chemical and water balance models. Tributary canyon sampling should focus on Capulin Canyon and, to some extent, on the South Sugar Shack area.

Similar water-quality and flow rate surveys should be conducted in Hanson Creek or Hot-N-Tot tributary canyons. Chemical and water balance models of the natural acidic system can then be compared to modeling results from Capulin Canyon, and an estimate of the proportion of acidic drainage related to natural and waste-rock dump sources evaluated.

Tritium analyses to date appear to distinguish post-1952 ground water ("young water") from mixed ground water (pre-and post-1952 water). Additional "age" data should be obtained from the valley-fill wells and the Portal Springs seeps opposite the Sugar Shack South waste-rock dumps. These data would supplement the hydrogeological model being developed for the area. A tritium value for the perched water at MMW-7 may be useful in better defining recharge sources.

See p. D-8, 9

X

A full complement of QA/QC documents indicating condition of the samples when taken, when received at the laboratory, and when analyzed should be maintained and methods of analysis should be documented.

4.4 BASIC DATA COLLECTION

Portrayal of the ground-water conditions in the Mine Area requires, at a minimum, water-level data for a period of a year. Precipitation data, stream gauge measurements, and changes in the river stages over the same period are also useful. It is necessary to look at seasonal relationships as well as any delayed impacts from the mine dewatering. Natural and man-induced discharges for the seeps and for adjacent tributary flows should also be included in the Mine Area data base. Any additional monitor wells would lead to better definition of the ground-water system.

SUMMARY OF RECOMMENDATIONS

- Perform surface geophysical surveys at the delta at Capulin Canyon and Goathill Gulch (including the unnamed tributary that lies just west of Shaft No. 1) using a seismic refraction technique. The primary purpose is to define the subsurface configuration of the bedrock valley floor and the thickness of the fan delta deposits.

- Perform a surface geophysical survey across the steep south sloping surface north of the Cabin Springs seeps. The primary purpose is to define permeable fracture zones that may be the source of the Cabin Springs seepage.

- Install a shallow (less than 50-foot TD) monitoring piezometer in the valley-fill in the mid-Capulin Canyon area. The purpose is to monitor water quality and to evaluate down-valley changes in quality relative to existing sampling points at the head and the mouth of the canyon.

- Install a valley-fill monitor/extraction well (TD of 130 feet) near the west end of the Sugar Shack South waste-rock dump and west of the existing valley-fill wells. The purposes of this well are to better define the flow system in the valley-fill, and to potentially aid in the extraction of ground water.

- Collect water-quality samples from the monitor wells in the Mine Area (and the tailings facility) using a bladder pump. Additional sampling may include the river and selected river bank seeps along with springs and seepages in the tributary canyons. This sampling should all be conducted at the same time to reflect any seasonal controls on the water quality.

- Conduct limited tritium analyses at MMW-10A, the Portal Springs seeps, and MMW-7.

- Develop a database based on one-year measurements of water levels, stream flow, precipitation, and changes in river stages.

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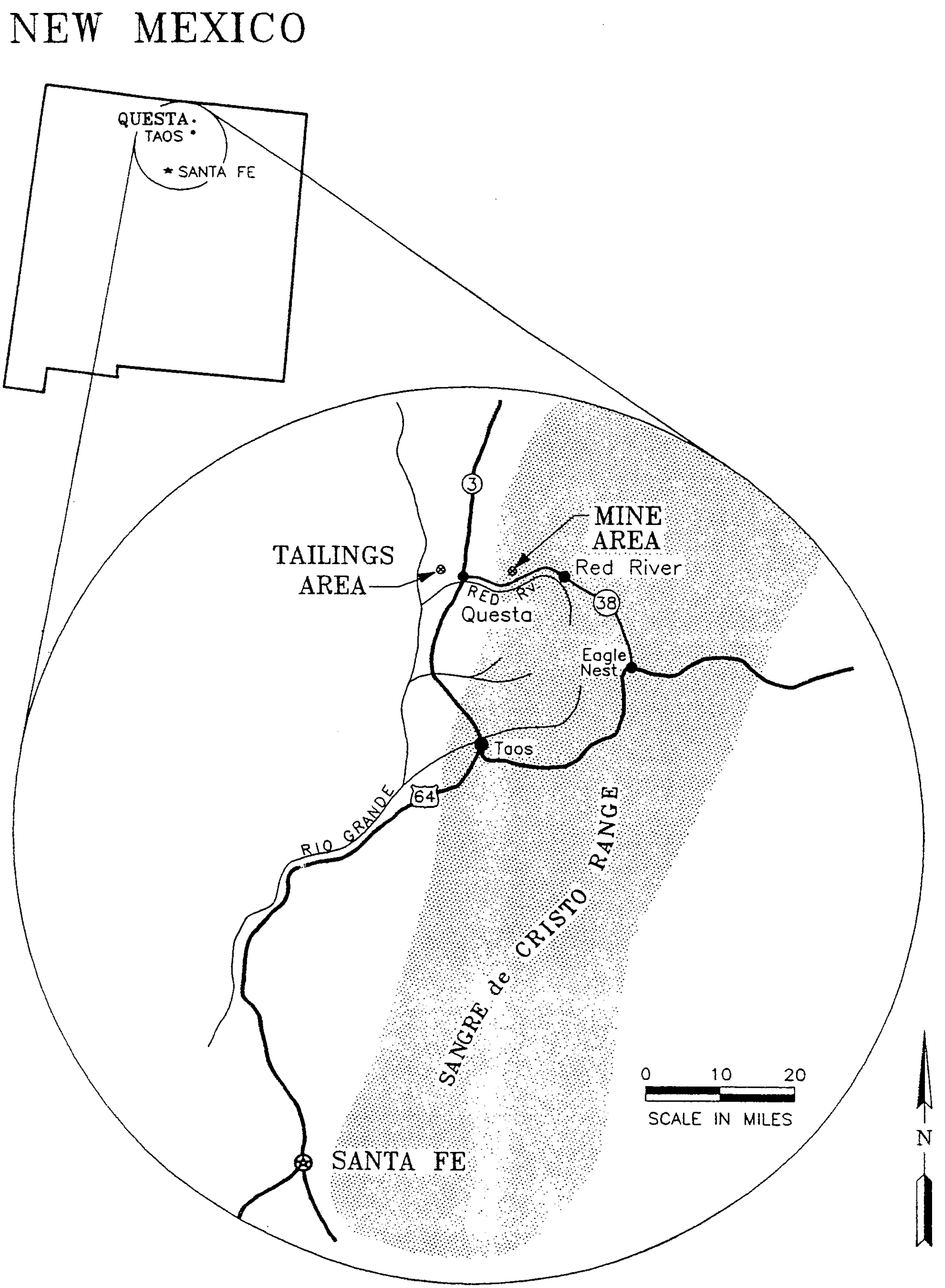
FIGURES

V-MAP



SOUTH PASS RESOURCES, INC.				REGIONAL LOCATION MAP Molycorp, Inc. Questa, New Mexico	FIGURE: 1
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.		

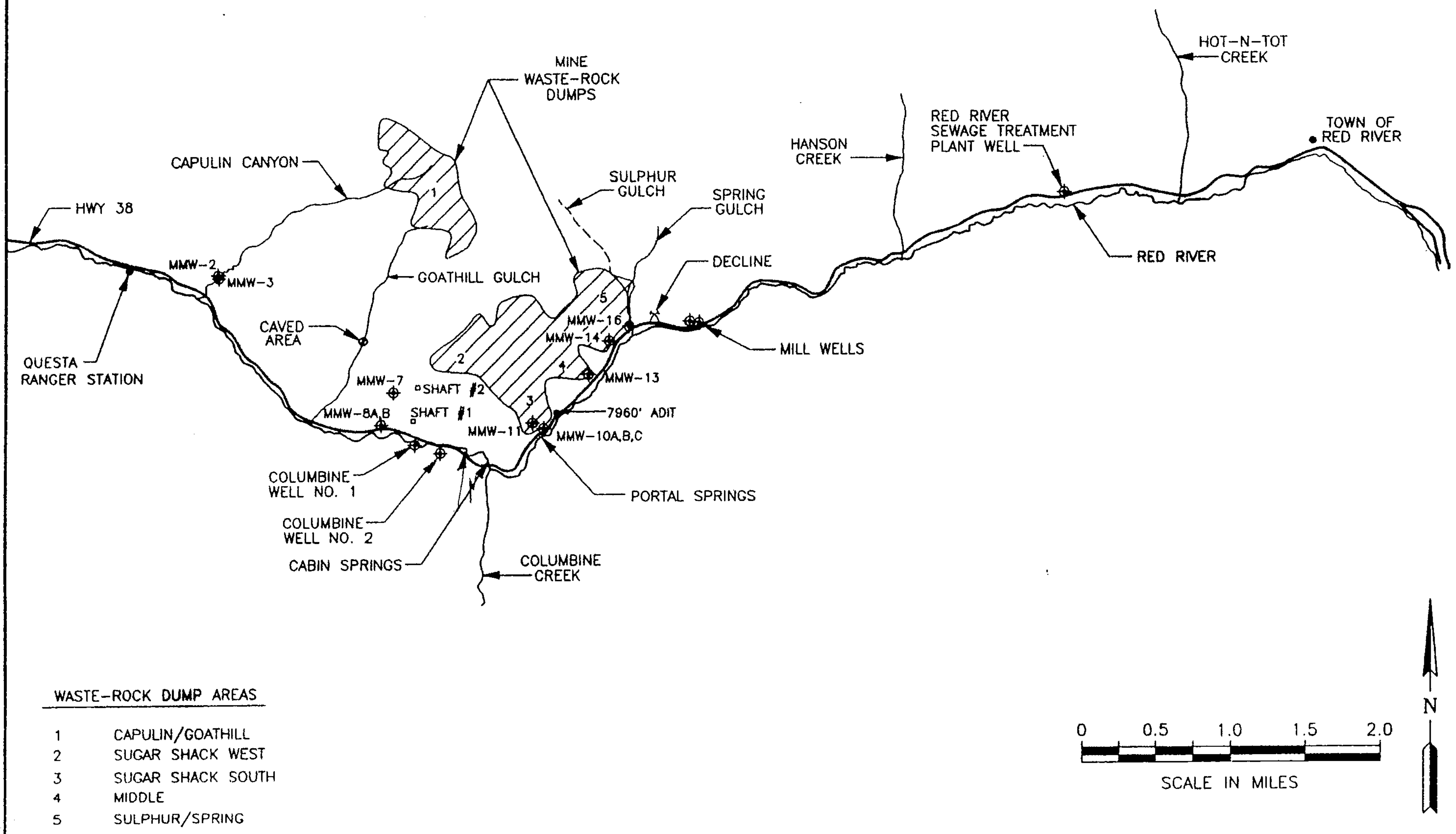
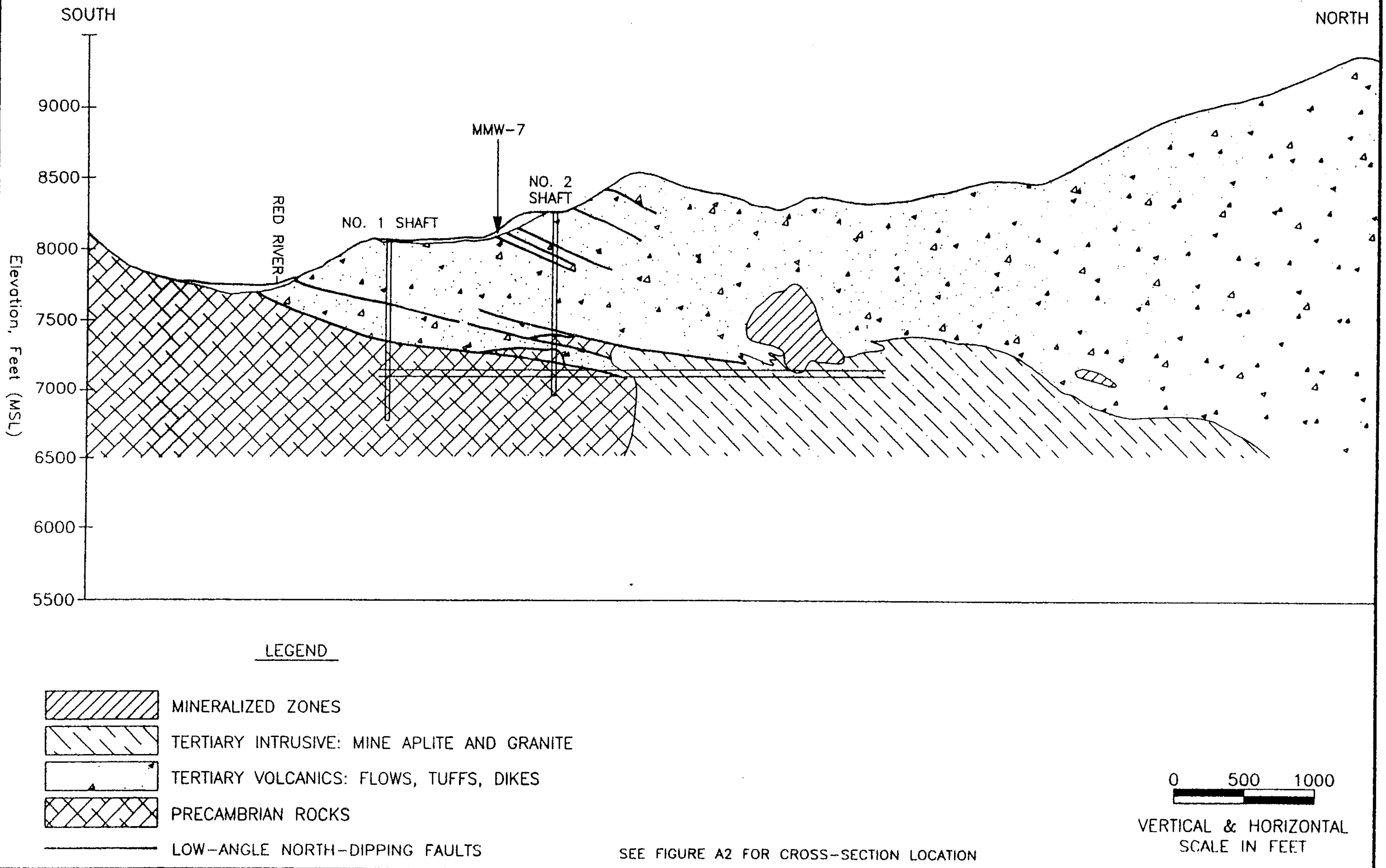


FIGURE:
2

SOUTH PASS RESOURCES, Inc.

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

MINE AREA SITE MAP
Molycorp, Inc.
Questa, New Mexico



SEE FIGURE A2 FOR CROSS-SECTION LOCATION

FIGURE 3

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001--06	4/21/95	JCK	M.O'M.

GEOLOGIC CROSS-SECTION A - A'

Mine Area - Molycorp, Inc.
Questa, New Mexico

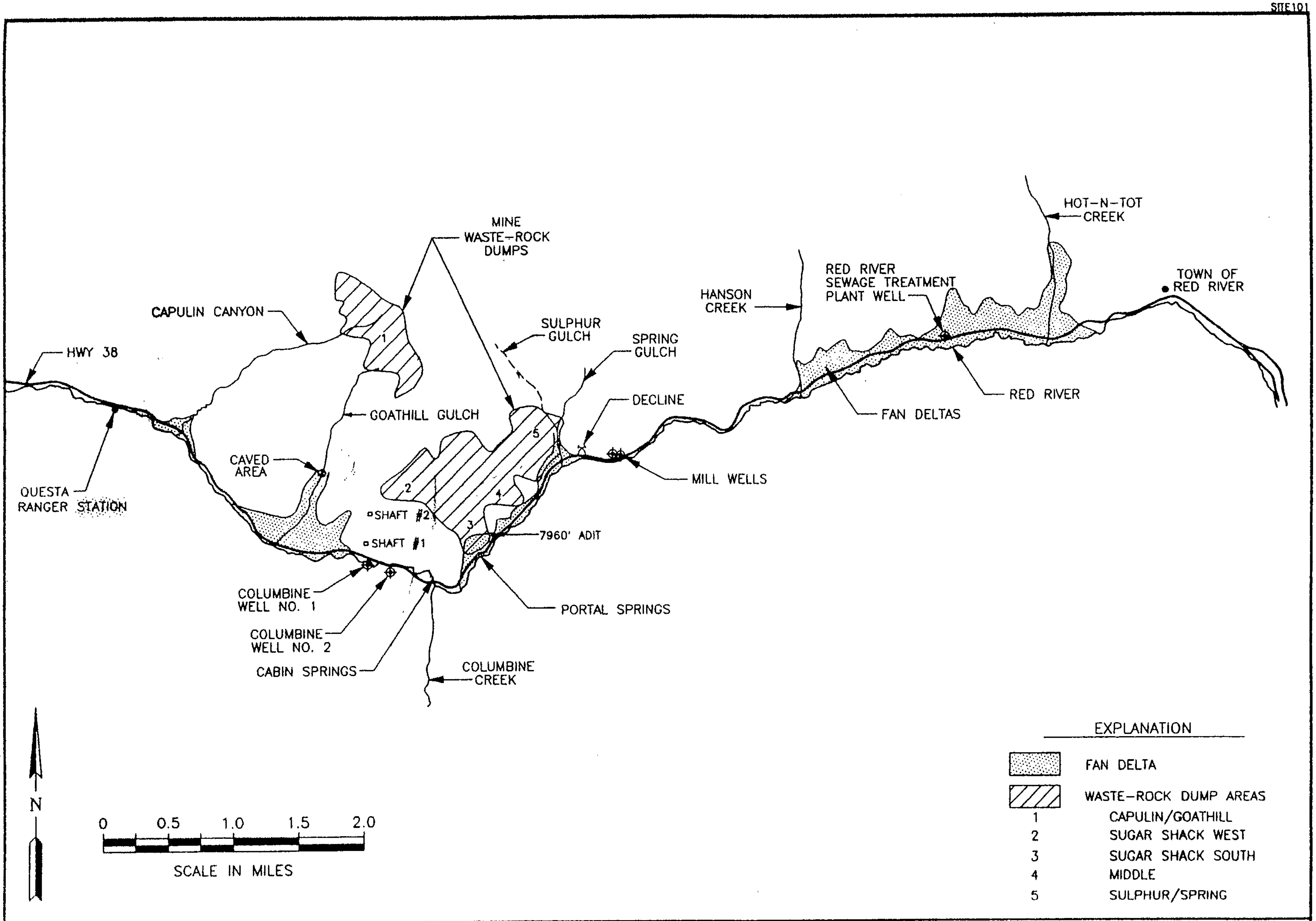


FIGURE: 4

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

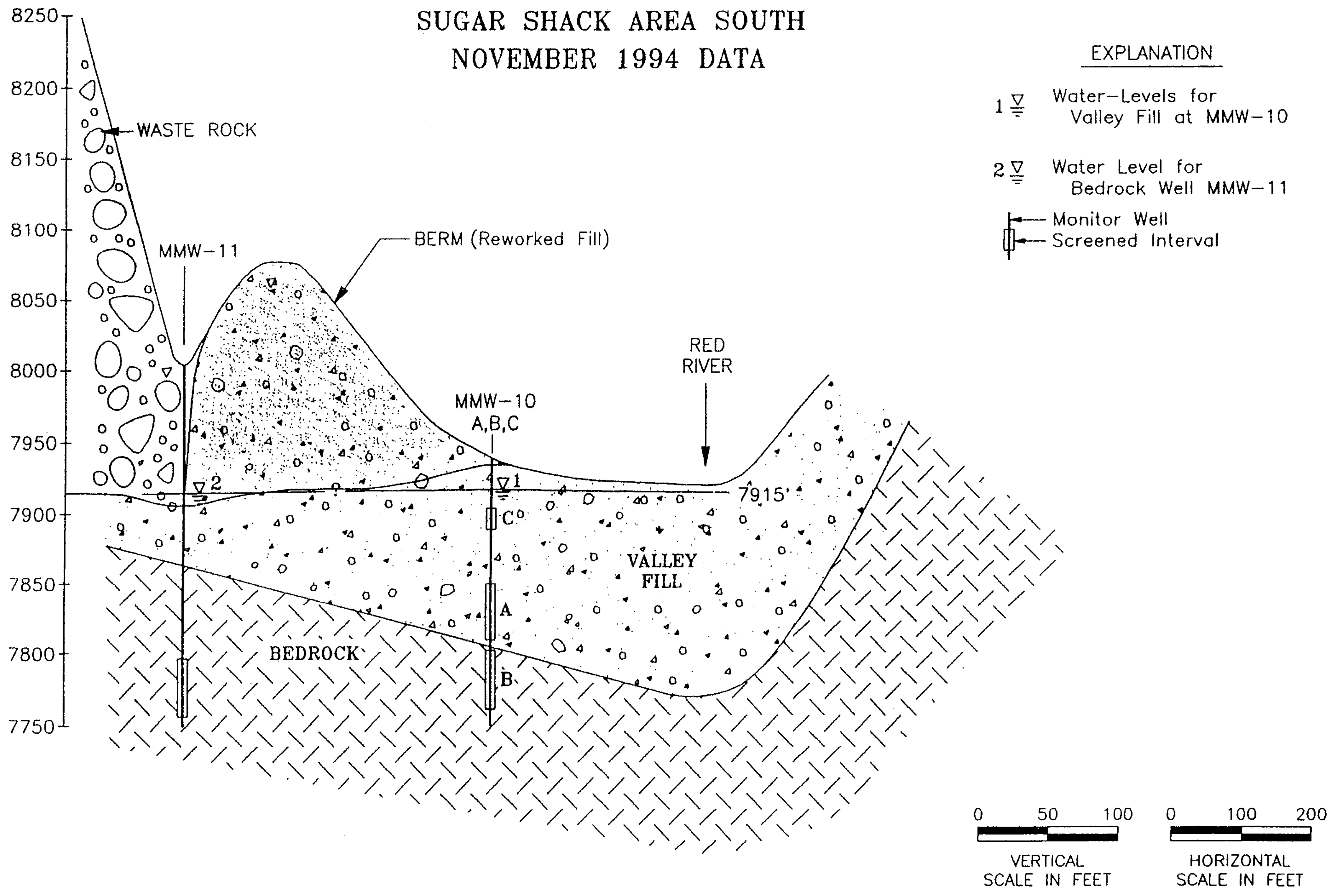


FIGURE:	SOUTH PASS RESOURCES, Inc.				HYDROGEOLOGIC CROSS-SECTION, SUGAR SHACK SOUTH
5	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	Mine Area – Molycorp, Inc. Questa, New Mexico

SUGAR SHACK WEST AREA
NOVEMBER 1994 DATA

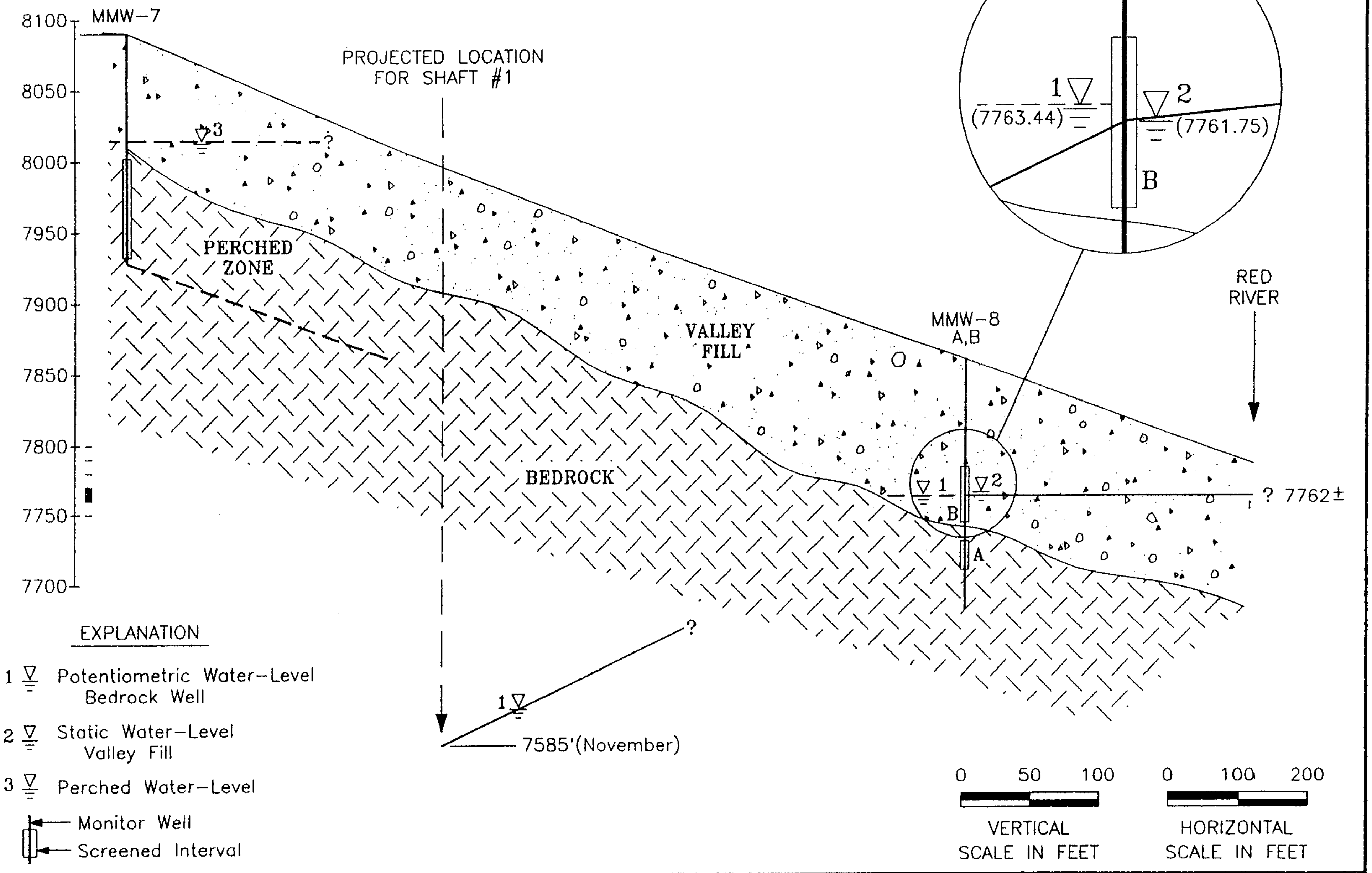


FIGURE: **6**

SOUTH PASS RESOURCES, Inc.

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

HYDROGEOLOGIC CROSS-SECTION, SUGAR SHACK WEST
Mine Area – Molycorp, Questa
New Mexico

CAPULIN CANYON

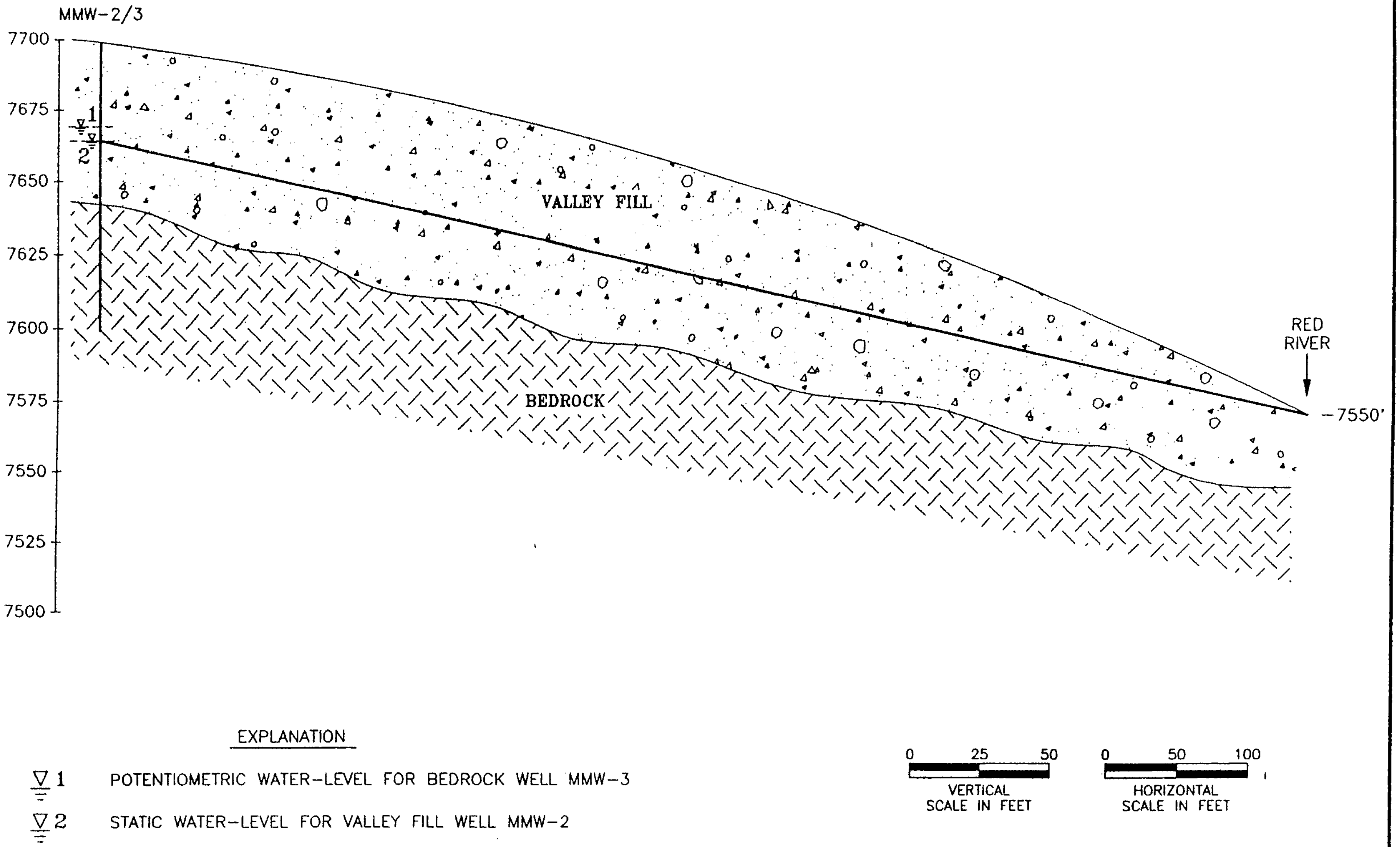


FIGURE. **7**

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

SITE 103

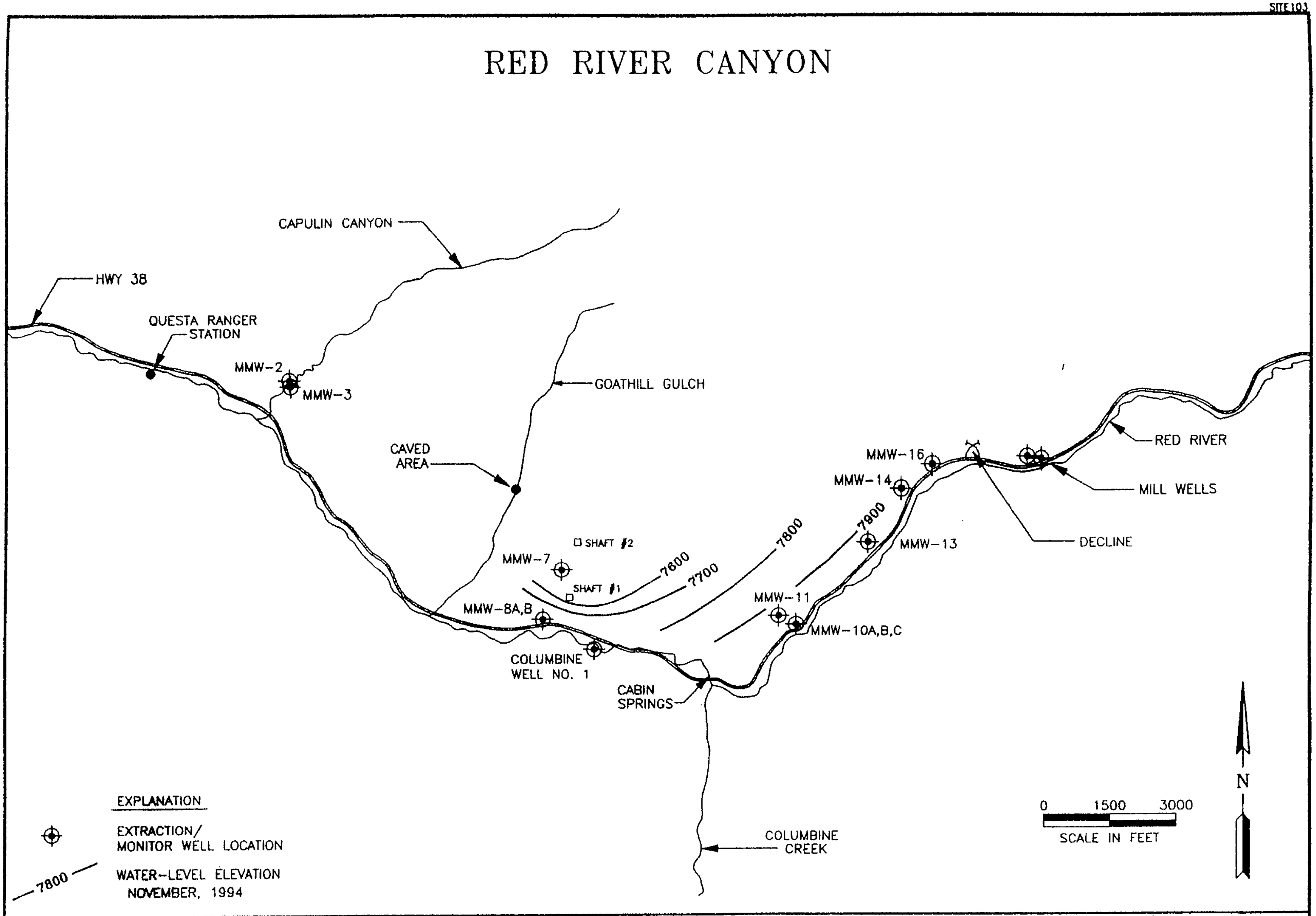


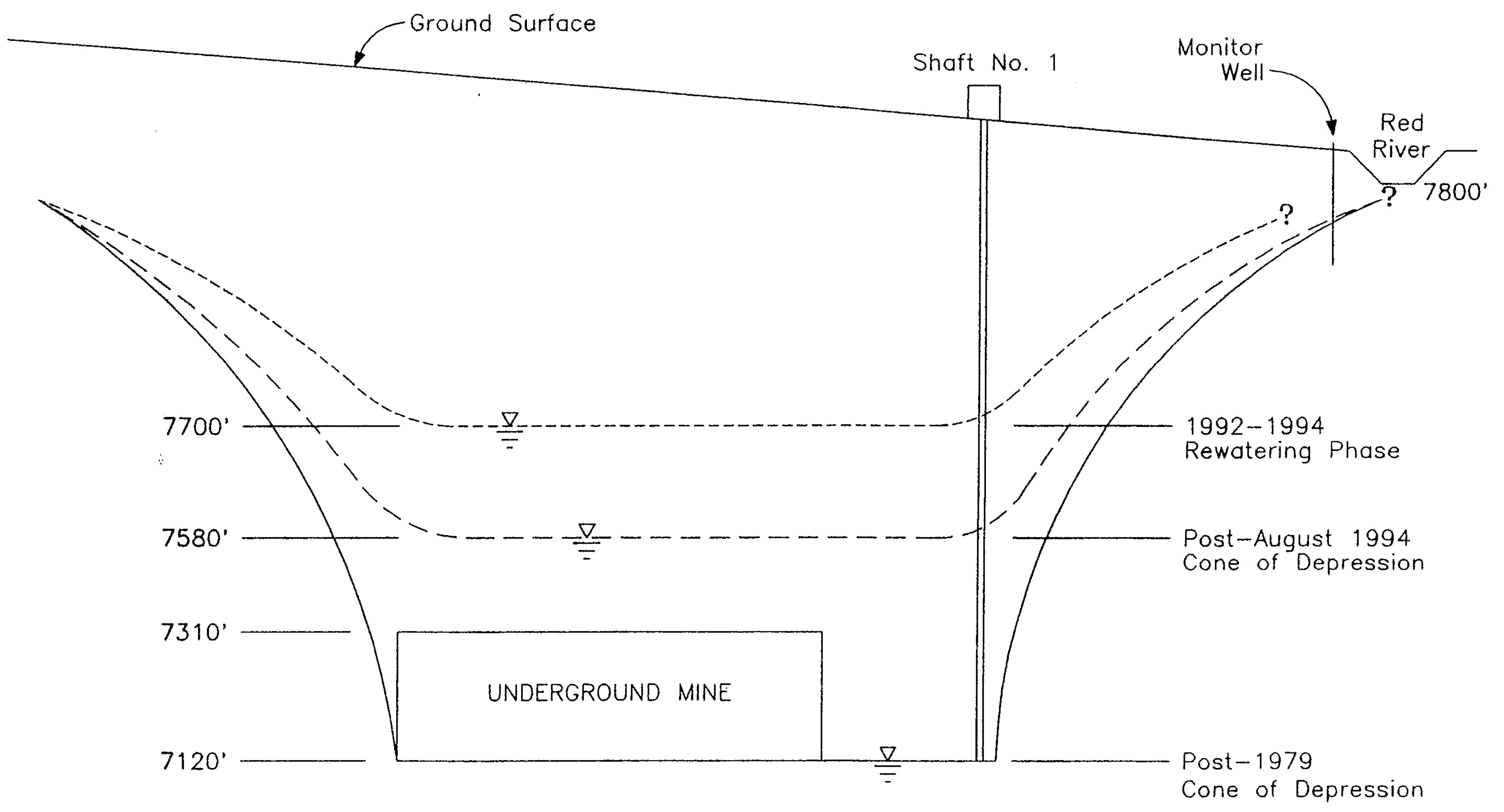
FIGURE: 8

SOUTH PASS RESOURCES, Inc.

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

GROUND-WATER CONTOURS FOR BEDROCK WELLS
Mine Area – Molycorp, Questa
New Mexico

XSEC-21



NOT TO SCALE

FIGURE 9

SOUTH PASS RESOURCES, Inc.

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

SCHEMATIC OF WATER–LEVEL CHANGES IN AREA OF THE UNDERGROUND MINE

Mine Area – Molycorp, Inc., Questa, New Mexico

SITE102

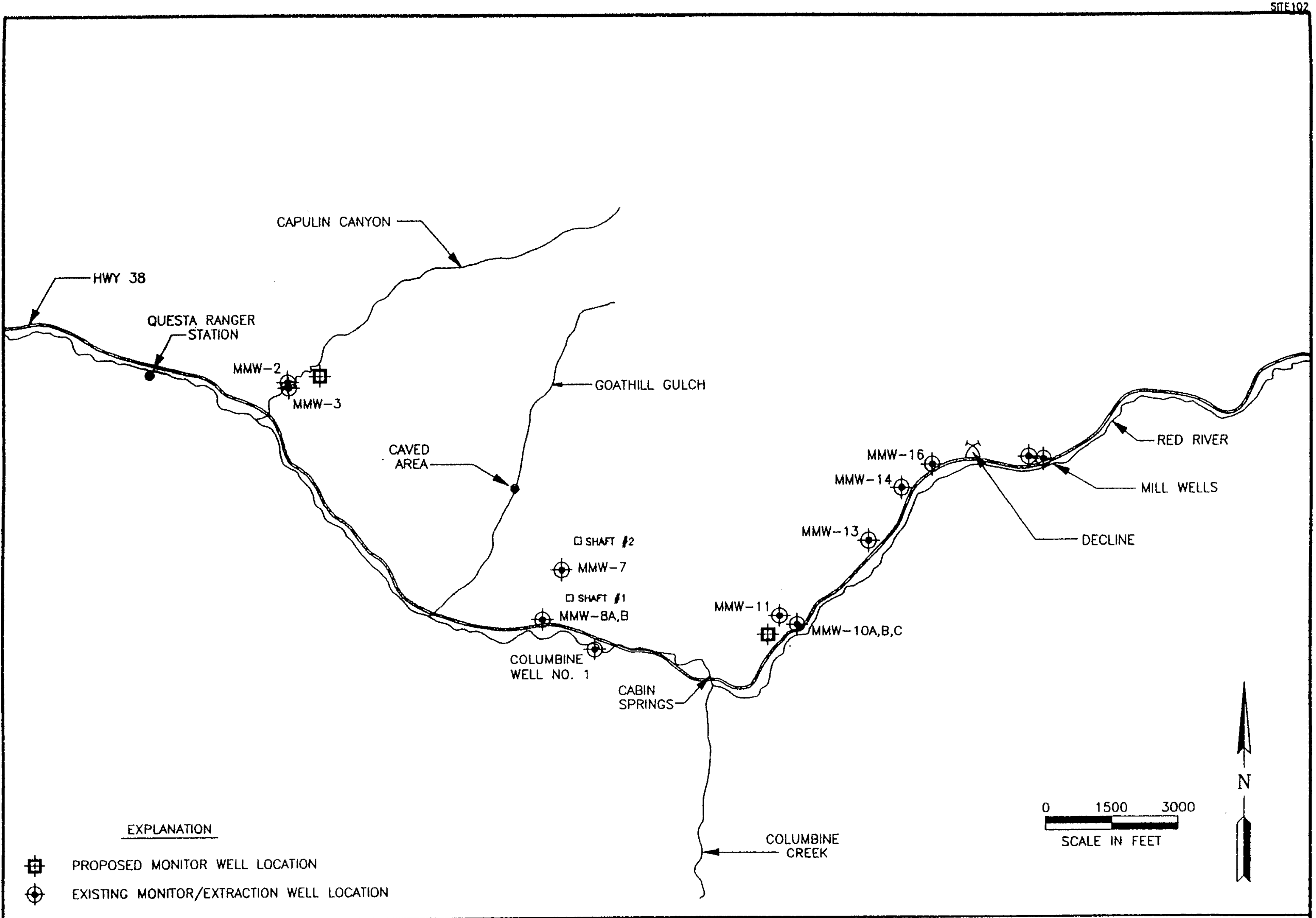


FIGURE: **10**

SOUTH PASS RESOURCES, Inc.

PROJECT No:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/21/95		M.O'M.

EXISTING AND PROPOSED MONITOR WELL LOCATIONS

Mine Area – Molycorp, Questa
New Mexico

TABLES

TABLE 1
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) (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)	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 1
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 1
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 2
COMPARISON OF WATER QUALITY DATA FOR SUGAR SHACK SOUTH and PORTAL SPRINGS
MOLYCORP, INC. - QUESTA, NEW MEXICO

MONITOR WELL/ SPRING	pH	TEMPERATURE (°C)	SULFATE (mg/L)	ALUMINUM (mg/L)
MMW-10A	5.80	7.8	1,100	33.4
MMW-10B	7.90	10.1	1,100	8.74
MMW-10C	4.70	11.8	880	31.1
MMW-11	5.60	15.7	1,300	56.3
Portal Springs	5.00	-	679.8	5.3

APPENDIX A

APPENDIX A

Discussion Of Mine Area Site Geology

APPENDIX A

Discussion of Mine Area Site Geology

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A.4 MINERALIZATION A-4

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Figure A2: Approximate Cross-Section Location
Figure A3: Geologic Cross-Section A-A'

TABLE

Table A1: Generalized Section of Rock Units in the Vicinity of the Mine Area

APPENDIX A

Discussion of Mine Area Site Geology

A.1 GENERAL GEOLOGIC SETTING

The major sources of geological data for the Mine Area are Schilling (1956), Rehrig (1969), Lipman (1981), Bookstrom (1981), and numerous unpublished maps, cross-sections, and reports by Molycorp geologists. A common thread to all of these geological studies is that the mineralization in the study area was related to Tertiary magmatism and hydrothermal solutions focused along an east- to northeast-trending structural zone. This structural zone is variously interpreted as part of a graben (Schilling, 1956); as a zone of intense faulting (called the Red River Structural Zone by Rehrig, 1969); and the southern part of the outer ring fracture zone that formed the outer wall of the Questa caldera (Lipmann, 1981; Bookstrom, 1981).

The development of the caldera and the associated volcanic and intrusive rocks was a late Oligocene to Middle Miocene event (27.2 million years to 22 million years before present) that overlapped in time and space with the regional rifting associated with the Rio Grande Rift system. The range-bounding high-angle fault along the west side of the Sangre de Cristo Mountains (about 5 miles west of the mine) is related to regional extension across the Rio Grande Rift and the uplift of the mountain range in Mid-Tertiary time. At least the later movements along this range-front fault are younger than the caldera structure because the outer ring fracture zone is truncated by the range-front fault.

A.2 ROCK UNITS

The oldest rock units exposed in the vicinity of the Mine Area are Pre-Cambrian amphibolites, quartz-biotite schists, metaquartzites, granite gneisses, and intrusive quartz monzonites. These units are overlain by an Early Tertiary conglomerate and sandstone unit followed by a complex sequence of Oligocene and Miocene rhyolitic to quartz latitic ashflow tuffs, breccias, and lava flows and a sequence of basalt/andesite lava flows. These volcanics are intruded by a number of dikes and small stocks or plutons that range widely in composition (quartz latite, rhyodacite, rhyolite, granite porphyry, and aplite). In the Mine Area, most of the molybdenum mineralization is found in the outer parts of the Mine Aplite (22 million years before present) and adjacent volcanic units. Table A1 presents a brief description of the major rock units in the Mine Area.

TABLE A1
Generalized Section of Rock Units in the Vicinity of the Mine Area

AGE	UNIT (Symbol)	DESCRIPTION
Quaternary	Valley-Fill Alluvium (QAL)	Gravel, sand, and silt. Dominantly in Red River floodplain/channel deposits. A minor component of tributary valley-fill. Colluvial material not distinguished on maps, but consists of angular material deposited at the base of slopes.
Quaternary	Valley-Fill mudflow (Qmf)	Boulder and finer gravel size material in a medium to coarse silty and clayey sand matrix. Mixture of angular subangular, subrounded material.
Quaternary	Valley-fill "limonite" cemented sediment (Qlcq, Qlcs)	Channel gravels and sand, mudflow deposits and spring deposits (near the river) cemented by rust-orange to black "limonite."
Tertiary Miocene	Intrusive Units (Tq, Tql, Tqp, Tap, Tri, Tmp)	Variety of intrusions (commonly post-Amalia formation) consisting of: quartz latite, aplite, quartz monzonite, granite, granite porphyry, as stocks, plugs, dikes, and sills. Major intrusions in the Mine Area include: Mine aplite Red River Granite Porphyry Goathill Gulch Granite Porphyry Log Cabin Biotite Granite
Miocene	Amalia formation (Trt, Tr)	Rhyolitic ash-flow Tuffs, poorly to densely welded; rhyolitic breccias (fragments of andesite and rhyolite); megabreccia blocks of andesite (outcrop size to blocks on the order of 1,000 feet long) enclosed in the Amalia Formation (often mapped as andesite-Tanbx). Blocks more abundant toward the river area and lower in the section. Estimated intra-caldera thickness: 7,000 to 10,000 feet. Caldera-fill unit.
Oligo-Miocene	Basalt (Tb)	Xenocrystic basalt, amygdaloidal basalt contains xenoliths of Pre-Cambrian rock. Occurs as megabreccia blocks in the Amalia Formation. Caldera-fill unit.
Oligocene	Porphyritic Quartz latite (Tgl)	Flows and tuffs above andesite. Some of the latite is intrusive. Partly caldera-fill unit.
Oligocene	Andesite (Tan fp, Tan mp, Tan cp, Tan bx post-script indicates megabreccia block)	Finely (fp), medium (mp), and coarsely (cp) grained undifferentiated andesite porphyry. Both autobrecciated and monautobrecciated. Found as megabreccia blocks in Amalia Formation. Caldera-fill unit.
Oligocene	Andesite (Tan fp)	Medium-grained andesite porphyry. Massive, some autobrecciation. Caldera floor unit.
Oligocene	Tertiary sediments (Tcgc, Tcgf, Ts, c= >10 cm, f= <10 cm	Cobble to pebble conglomerate grading up into sandstone and siltstone. Channel structure (100 to 300 ft. thick). Finer grained upper section 50 to 300 ft thick. Consists of sandstone/siltstone with minor conglomeritic.
Pre-Cambrian	Pre-Cambrian basement (pꞒq, pꞒgn, pꞒd)	Quartzite, amphibolite schist, quartz-biotite schist, gneisses, granite gneisses intruded by pegmatite and diabase dikes and granite to quartz monzonite plutons.

A.3 STRUCTURE

Geological maps of the Mine Area (Figure A1) show a northeast- to east-trending structural zone (see Caldera boundary on Figure A1) along which intrusions of granitic rock and mineralization have occurred. This zone more or less parallels the Red River in the vicinity of the mine but farther to the west, swings to the southwest, away from the river. The structural zone is believed to be the southern part of the outer ring fracture zone (outer wall or rim) for the Questa Caldera. The zone is characterized by a swarm of east-trending dikes, elongated intrusions, and mineral veins that were emplaced in fractures developed parallel to the caldera rim.

South of the structural zone, northeast- and northwest-trending high-angle faults extend throughout the Pre-Cambrian block (Pre-Cambrian rocks and some pre-caldera volcanic rocks). Some of these faults are truncated by the caldera wall. North of the structural zone, the geology is more complex. Fault-bound blocks of Pre-Cambrian rock, pre-caldera volcanics, and younger caldera-related volcanics occur throughout the area. These structural blocks and the outer fracture zone along the caldera wall became the plumbing system through which granites intruded (such as the Mine Aplite) and the later mineralizing hydrothermal waters migrated.

A variety of fractures developed throughout the caldera block. These include:

- high-angle joints (called sheeting in the aplite) and fracture cleavage;
- contact conformable fractures between the intrusions and the volcanic units;
- high-angle northeast-, north-, and northwest-trending faults; and
- low-angle faults both within the Mine Aplite (west- and north-dipping) and as structural contacts between various Tertiary units.

Major northerly-trending high-angle faults that could have an influence on ground-water flow paths include the Goathill Fault, the Neck Fault, and a series of unnamed faults east of the Neck Fault (Figure A2). The low-angle faults are presented in a north-south cross-section on Figure A3. These are probably related to listric (concave-up fault planes), normal faults developed along the caldera boundary, and/or large slide blocks derived from the walls of the caldera. Within the structural zone mine, geologists have mapped volcanic megabreccias that may be representative of slide blocks.

Detailed surface and subsurface mapping (Molycorp files) shows a complex of low- and high-angle faults of different ages. The character of the individual faults ranges from tight mineralized fractures (quartz + sulfide ± calcite ± fluoride) to faults with an abundance of clay gouge to open structures. Segments of the Neck Fault exposed in the underground mine have been described as "water bearing" by Molycorp staff. Extensive east/west- to west/northwest-striking faults dip northward at an angle varying from nearly horizontal (0°) to vertical (90°). Most of these faults formed early during mid-Tertiary tectonism. The north- to northwest-striking high-angle faults are believed to be normal faults with down to the east separation. Some of these faults have a strike-slip component. Northeast-striking high-angle faults are also present. Some of these are truncated by the early east/west structures, but some are much younger.

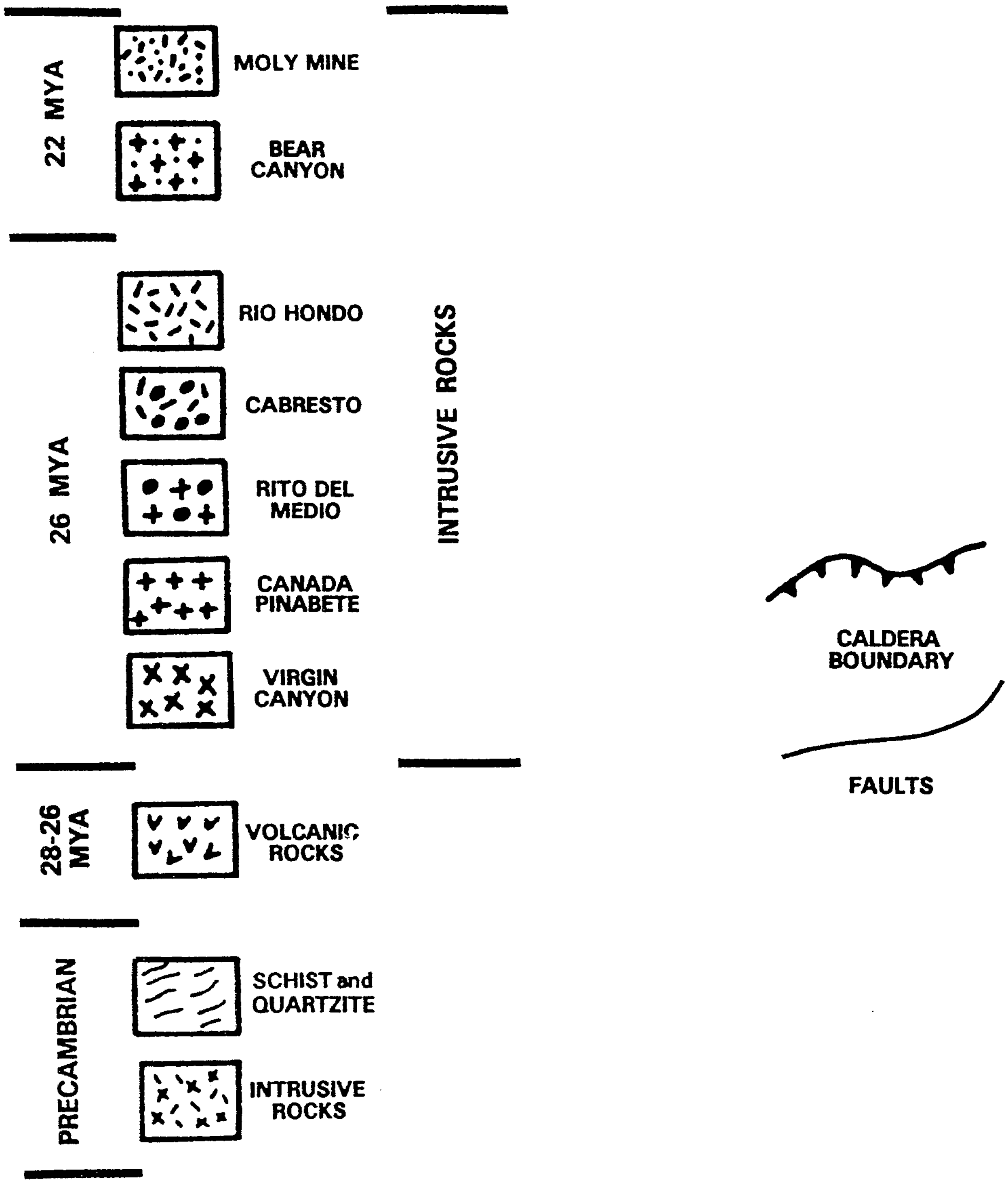
A.4 MINERALIZATION

The mineral deposits in the Mine Area consist of molybdenite-bearing quartz veins. The vein fillings occur in east- to northeast-striking, nearly vertical fractures in the Mine Aplite and in the immediately adjacent andesitic flow rocks intruded by the Aplite. Pyrite (iron sulfide) is fairly abundant in the quartz veins (with or without molybdenite) and in the clay gouges that fill some of the fault zones. It is also widely disseminated in the volcanic and intrusive rocks. Calcite, fluorite, and biotite are commonly associated with the vein minerals. The major alteration mineral in the volcanics outside of the veins is chlorite. Field photographs by Rehrig (1969) indicate that many fractures and small faults are barren of mineralization.

Schilling (1956) described intense zones of alteration associated with hydrothermal pipes (i.e., steeply inclined breccia structures) that probably formed at fault/fracture intersections in the volcanic rocks overlying the intrusion. The alteration minerals in these pipes consist of pyrite, chalcopyrite, quartz, kaolinite, sericite, and carbonates. Subsequent descending oxidizing ground waters reacted with the pyrite and carbonate minerals to form limonite (iron oxide), jarosite (hydrous iron/potassium sulfate), and gypsum (hydrated calcium sulfate) -- creating the yellow- and red-colored hydrothermal scars common throughout the area.

More recent regional mapping [U.S. Soil Conservation Service (USCS), 1982 aerial photograph map sheets 50 and 51] demonstrates that the hydrothermally altered areas (hydrothermal scars or rock outcrop - Badlands Complex - RdG) underlie most of the land between the Cabresto Canyon and Red River Canyon divide and the river. Every tributary canyon north of the river includes large exposures of hydrothermally altered pyritic rock. Two large areas south of the river, Bear Canyon drainage and several drainages west of Pioneer Creed (Town of Red River area), are also underlain by this type of pyritic rock. The USCS describes hydrothermally altered areas as typically sparsely vegetated, steeply-sloped badlands topography characterized by extremely acidic soil material. These steep surfaces are the source of much of the mudflow material deposited in the fan deltas at the mouths of the tributary canyon. Therefore, mudflow debris becomes another source of acidic drainage. The potential for natural acidic seeps and springs throughout the area, including the mine property, is high. Hanson Creek and Hot-N-Tot natural acidic drainages are an example of these conditions east of the mine property.

Schilling (1956) reported that iron-enriched mine drainage waters precipitated limonite near the portal to Z Tunnel (old underground workings) and that pre-mine alluvial deposits cemented by limonite occur in the upper Sulphur Gulch drainage above the older workings. During field reconnaissance, SPRI geologists observed that limonite-cemented alluvial material occurs in the lower part of Goathill Gulch near State Route 38, on an outcropping of cemented gravels on the north side of State Route 38, west of the cabins, and throughout a 75-foot thick section of a mudflow deposit just west of lower Hanson Creek near the highway. During the drilling of MMW-16 at Sulpher Gulch, a 10-foot section of limonite-cemented gravel was encountered at a depth of 36 to 46 feet. A thin (less than 1-foot thick) bed of limonitic sediment was exposed a few feet below the recent alluvial surface in bank exposures along the Red River. All of these occurrences indicate that the natural oxidation processes occurring at present have a very long pre-mine history.



REFERENCE: MOLYCORP FILES.

SOUTH PASS RESOURCES, Inc.

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

GENERALIZED GEOLOGIC MAP KEY

Mine Area – Molycorp, Inc.
Questa, New Mexico

FIGURE: A1a

XSEC-MAP

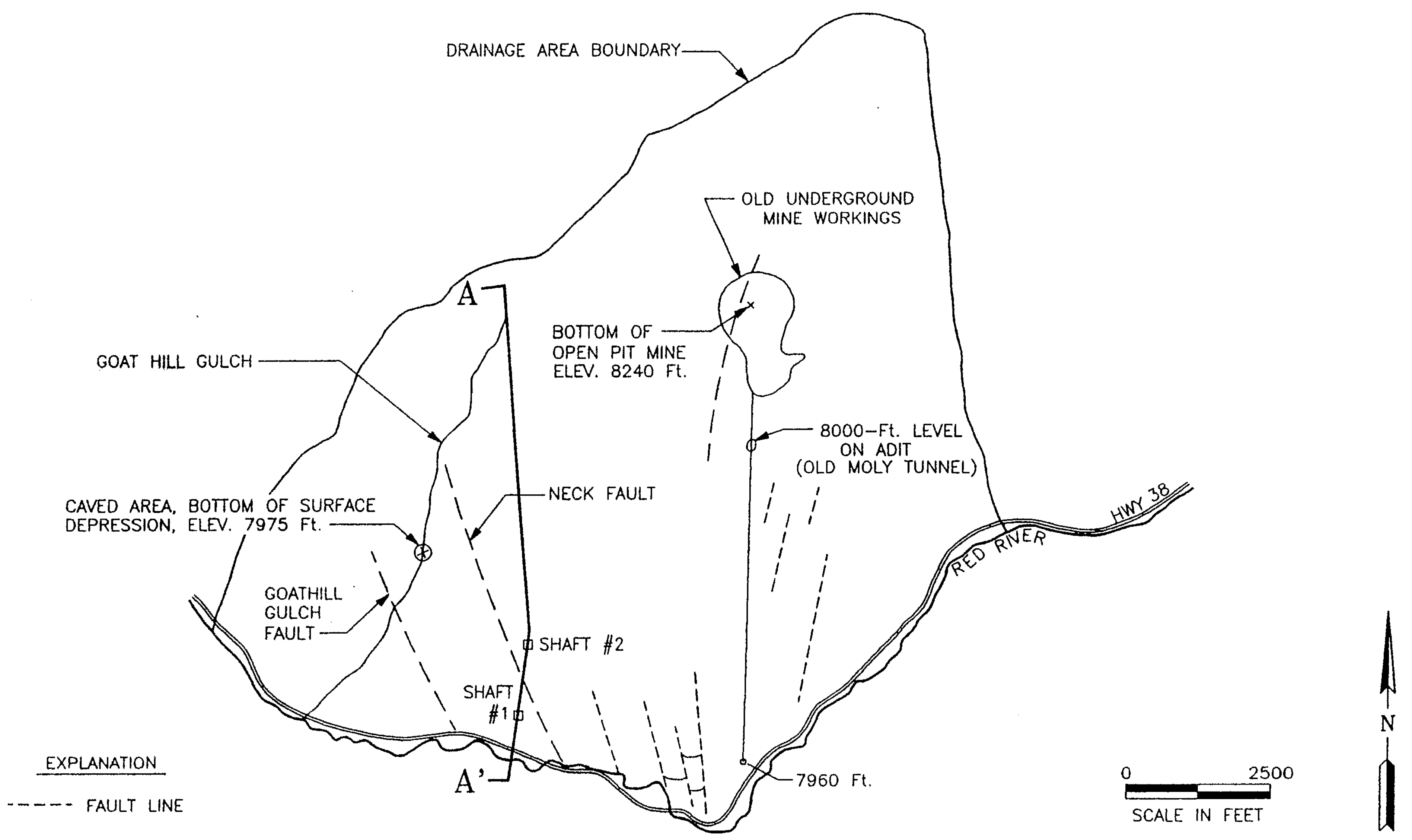


FIGURE: **A2**

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

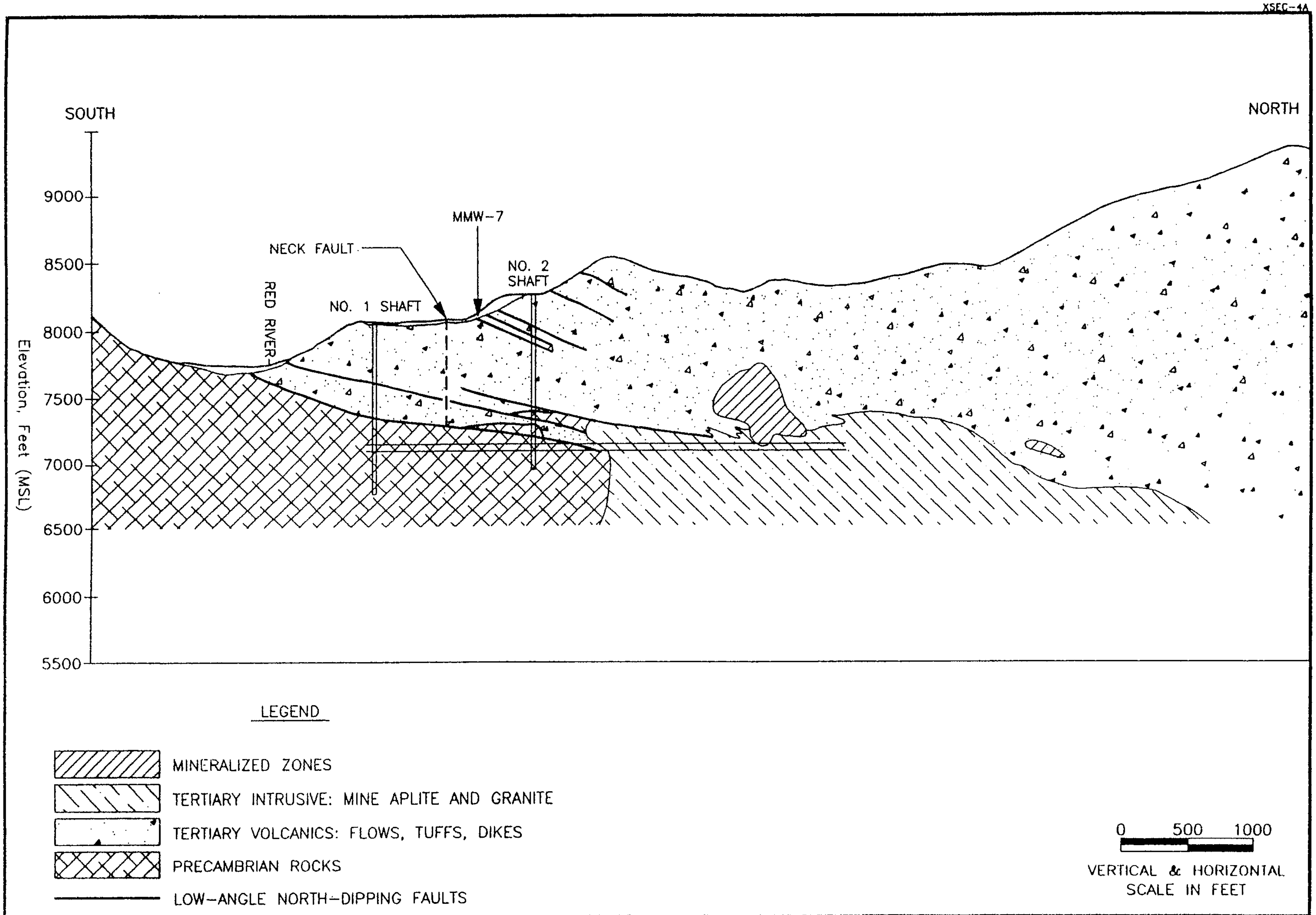


FIGURE:	SOUTH PASS RESOURCES, Inc.				GEOLOGIC CROSS-SECTION A – A'
A3	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR: JCK	DRAWN BY: M.O'M.	Mine Area – Molycorp, Inc. Questa, New Mexico

APPENDIX B

APPENDIX B

Discussion Of Mine Area Hydrogeology

APPENDIX B

Discussion Of Mine Area Hydrogeology

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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.

Schilling's (1956) and Rehrig's (1969) descriptions of the fracture systems and field examination of rock exposures in the same area indicate that open fractures exist (some fracturing can be related to mine activities). It is also likely that these low flow rates can be attributed to perched fracture water above a regional water table. The deeper underground workings dewatered at 250 to 500 gpm. [For comparison, Newmont's Gold Quarry Mine in Nevada is in fractured sedimentary rock and dewaters at 50,000 gpm (Carrillo, 1993).] However, if the fractures in a mineralized zone were partly sealed by mineralization/clay gouge and/or poorly interconnected, then 500 gpm, even below the water table, would not be unreasonable. It is possible that the open pit and most of the older underground workings near Sulphur Gulch (down to 7,800 to 7,900 feet) were above the regional water table and that the inflows were from perched water. Currently, this inflow from the open pit and the older underground mine drains though a borehole into the deeper mine workings.

If the gaining stream model is used with the equipotential lines (contours of equal water-level elevation) nearly normal to the flow direction of the river, such a contour surface would allow for most of the old workings and the pit to be relatively dry and above the regional water table. The Moly Tunnel (7,960 adit) would be at the water table at an elevation of 8,000 feet. Construction of the 7,960 adit did not produce much water and, therefore, the 8,000-foot water-level contour might have curved more to the north. This water-table surface would have a southwesterly gradient of 0.036 foot/foot in this very simplified configuration. If the equipotential lines were parallel to the river, most of the old workings and part of the open pit would have been below the pre-mine water table.

A simplified water-table surface with the equipotential lines at a right angle to the river can be used to estimate the elevation of the water table in various areas of the underground workings. For example, the water level would continue to rise in the caved area above the underground workings in the Goathill Gulch area to an elevation of approximately 7,840 feet. At Shaft No. 1, the elevation would be about 7,820 feet and at Shaft No. 2, it would be closer to 7,850 feet. With respect to the old Moly Tunnel (7,960 adit), a conservative position would place it just below the water table at about 8,000 feet.

Another element in the water-table surface configuration is the additional recharge from seepage barriers to the mine through the caved area. This recharge currently amounts to about 70 gpm captured by the seepage barriers constructed on Capulin and Goathill Gulches. An additional 30 gpm drains from the open pit through a borehole in the old underground mine to the deeper workings. This amount of seepage water is occasionally strongly augmented by surface water related to storm discharge and snow melt such that recharge to the caved area can exceed several hundred gpm. How much of this water actually reaches the caved area is unknown since it is a surface discharge and a certain amount must be lost to evaporation or infiltration to the vadose zone. (In the vadose zone, the water would be bound by surface tension in intergranular voids or micro-fractures.) It is possible that the additional recharge might cause some mounding of the water table surface, particularly in the caved area, and locally a slightly steeper gradient. A concern here is that water-level mound in the caved area might extend to the valley-fill in Goathill Gulch from which it could more easily reach the river.

Rate of Rise for the Water Table

On May 19, 1994, the water level in the mine workings was at 7,600 feet. According to Molycorp records, the caved area began to fill by October 20, 1992. Using the elevation of the bottom of the caved area (7,226 feet) and the time since filling began (549 days), the rate of rewatering is 0.68 foot/day. The actual daily rate values range from less than 0.68 to as much as 2.0 feet/day, depending on seasonal recharge conditions. However, if the 0.68 foot/day is used as the rate, it would take 147 days (from May 1994) for the water level to rise to the down-gradient elevation (7,700 feet) of the Red River. (This assumes a southwestern gradient based on the normal contour configuration in the caved area at Goathill Gulch). In other words, after 147 days (0.4 year) from May 1994, there would be a slight gradient from the cave area toward the river. Using the same rate of 0.68 foot/day, it would take 0.97 year to reach the postulated water-table elevation of 7,840 feet in the caved area. However, as noted in the previous paragraph, localized high recharge rates in the caved area could cause mounding and water would be higher and at an earlier date than the 0.68 foot/day rate predicts. In the case of the Moly tunnel (7,960 feet), it would require 1.61 years for the water level to reach 8,000 feet and begin to flow down to the adit.

Monitor wells constructed in 1994 were designed to capture tributary discharges to the valley-fill and bedrock aquifers. Not enough wells were sited in a single aquifer to evaluate flow directions or hydraulic gradients.

B.4 AQUIFER TESTS

An aquifer test conducted in the valley-fill at MMW-10A resulted in a calculated transmissivity of 123,200 gallons per day per foot (gpd/ft) and a hydraulic conductivity of 1,141 gpd/ft^2 (based on an aquifer thickness of 108 feet). These are reasonable values for the coarse sand and gravel encountered in this well. However, the maximum pump yield was 140 gpm, and the aquifer was not stressed.

Almost all of the bedrock wells went dry during development (air-lift). Bladder pumps were utilized in sampling these wells, and yields were typically a few gallons per minute or less. The exception to the low yield during development was MMW-11, which yielded 60 gpm with less than one (1) foot of drawdown. The high yield probably resulted from this well 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:

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

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

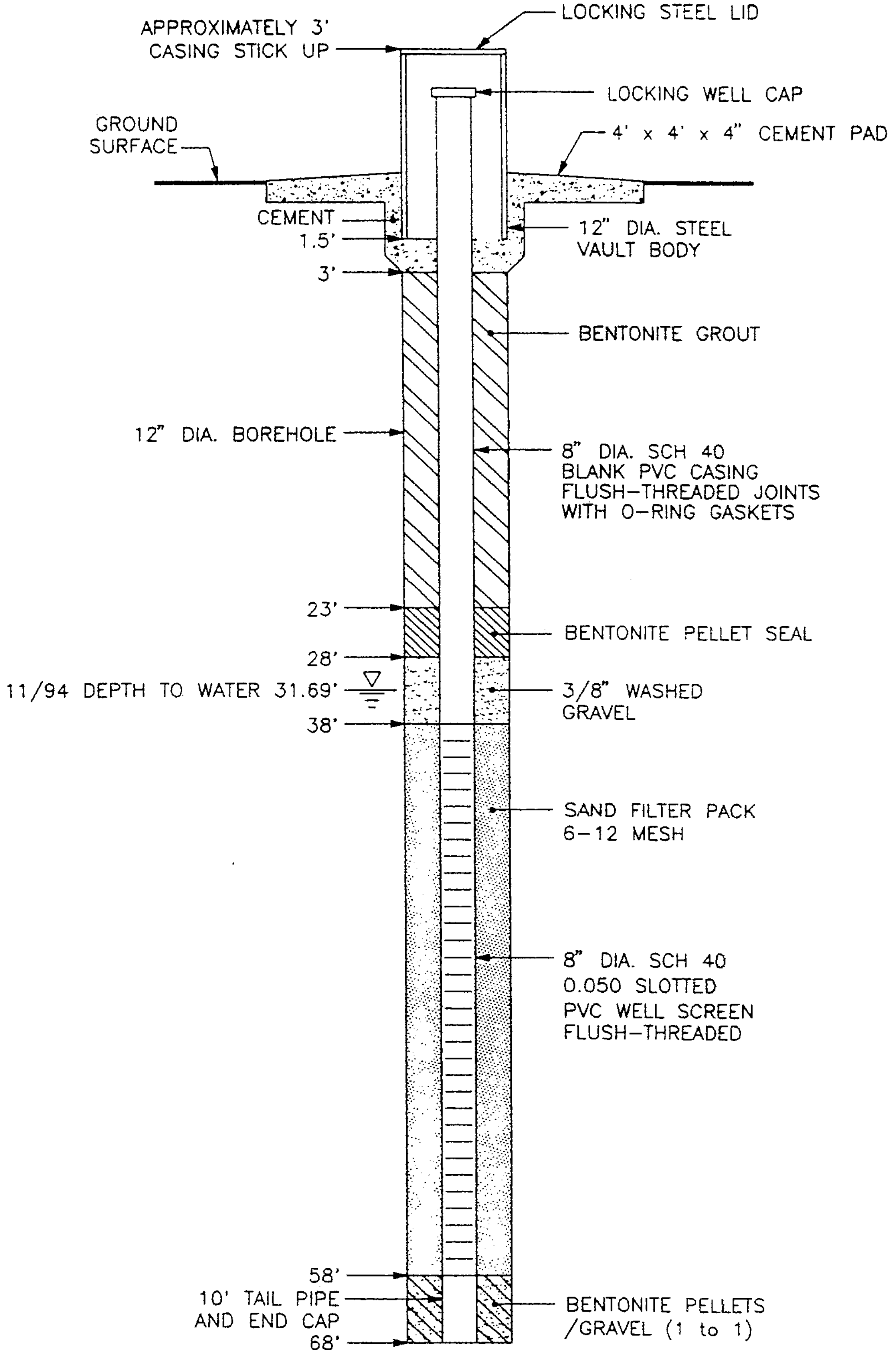
SOUTH PASS RESOURCES, Inc.
SPRI

APPENDIX C

Mine Area Borehole Logs

(from Fall 1994 Field Investigations)

MMW-2



SCHEMATIC OF WELL CONSTRUCTION

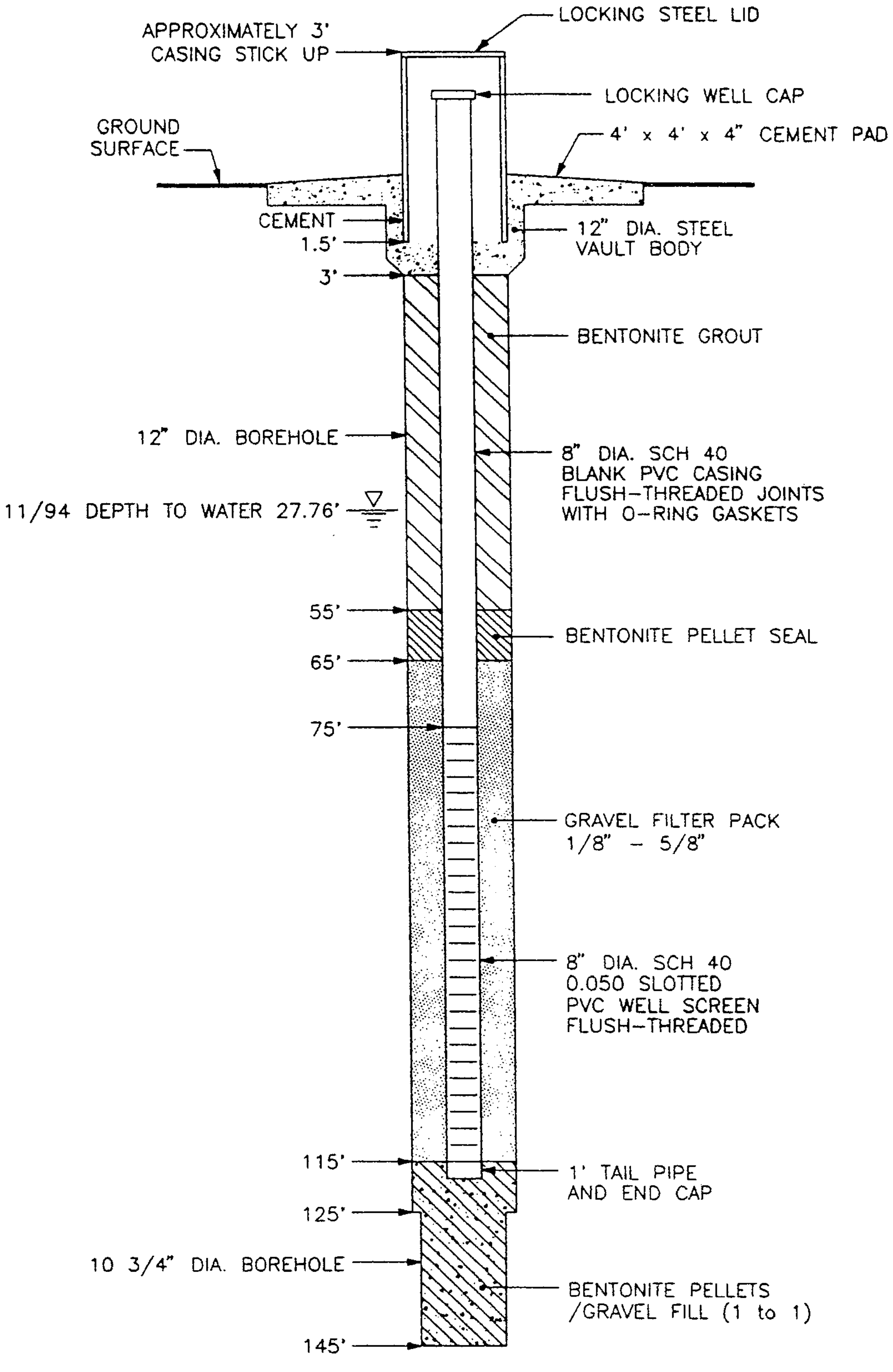
NOT TO SCALE

SOUTH PASS RESOURCES, Inc.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-05	2/20/95		M.O'M.

MONITOR WELL MMW-2
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C1

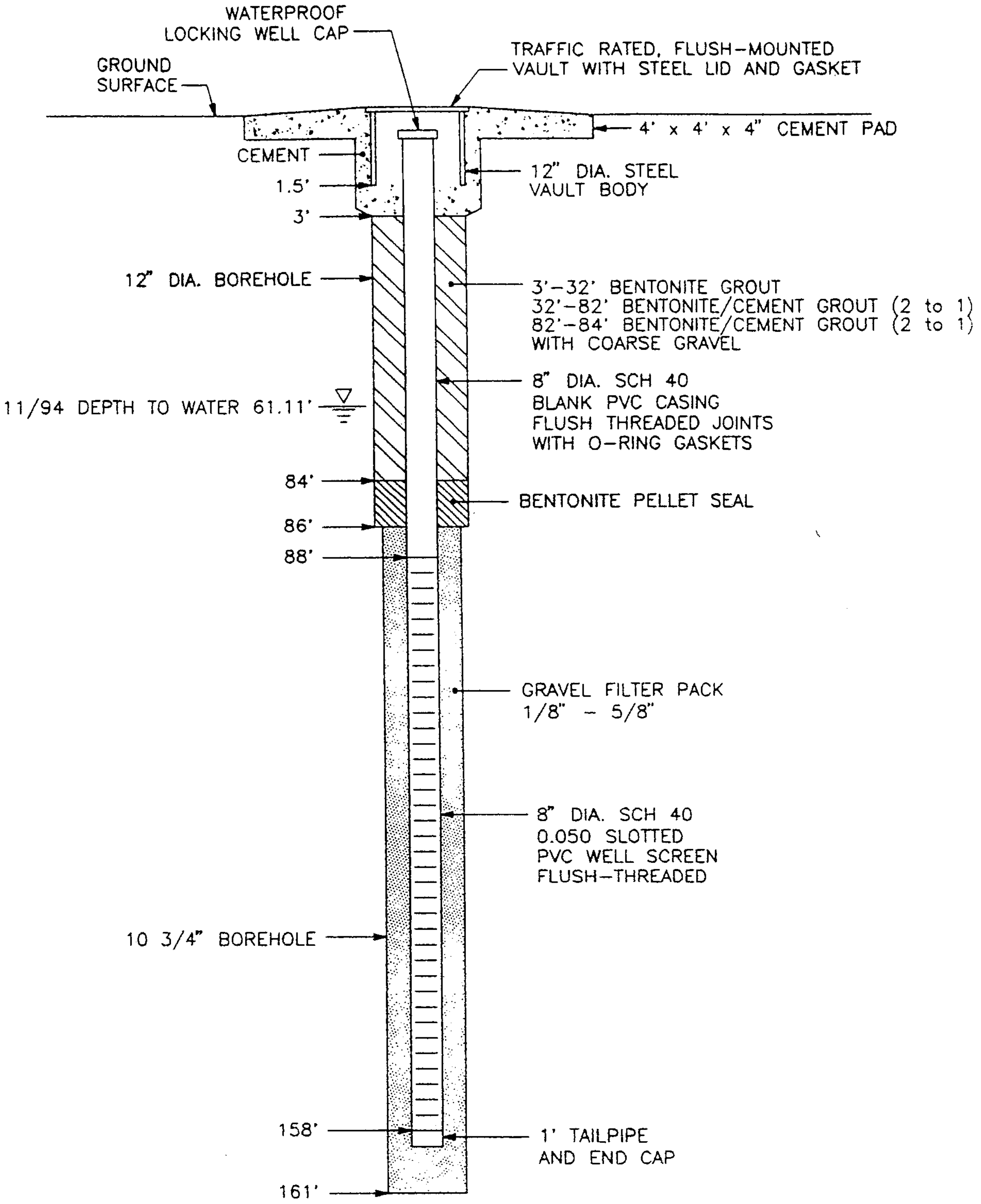


NOT TO SCALE

SCHEMATIC OF WELL CONSTRUCTION

SOUTH PASS RESOURCES, Inc.				MONITOR WELL MMW-3 Molycorp, Inc. Questa, New Mexico	FIGURE: C2
PROJECT No.: 001-05	DATE: 2/15/95	AUTHOR:	DRAWN BY: M.O'M.		

MMW-7



SCHEMATIC OF WELL CONSTRUCTION

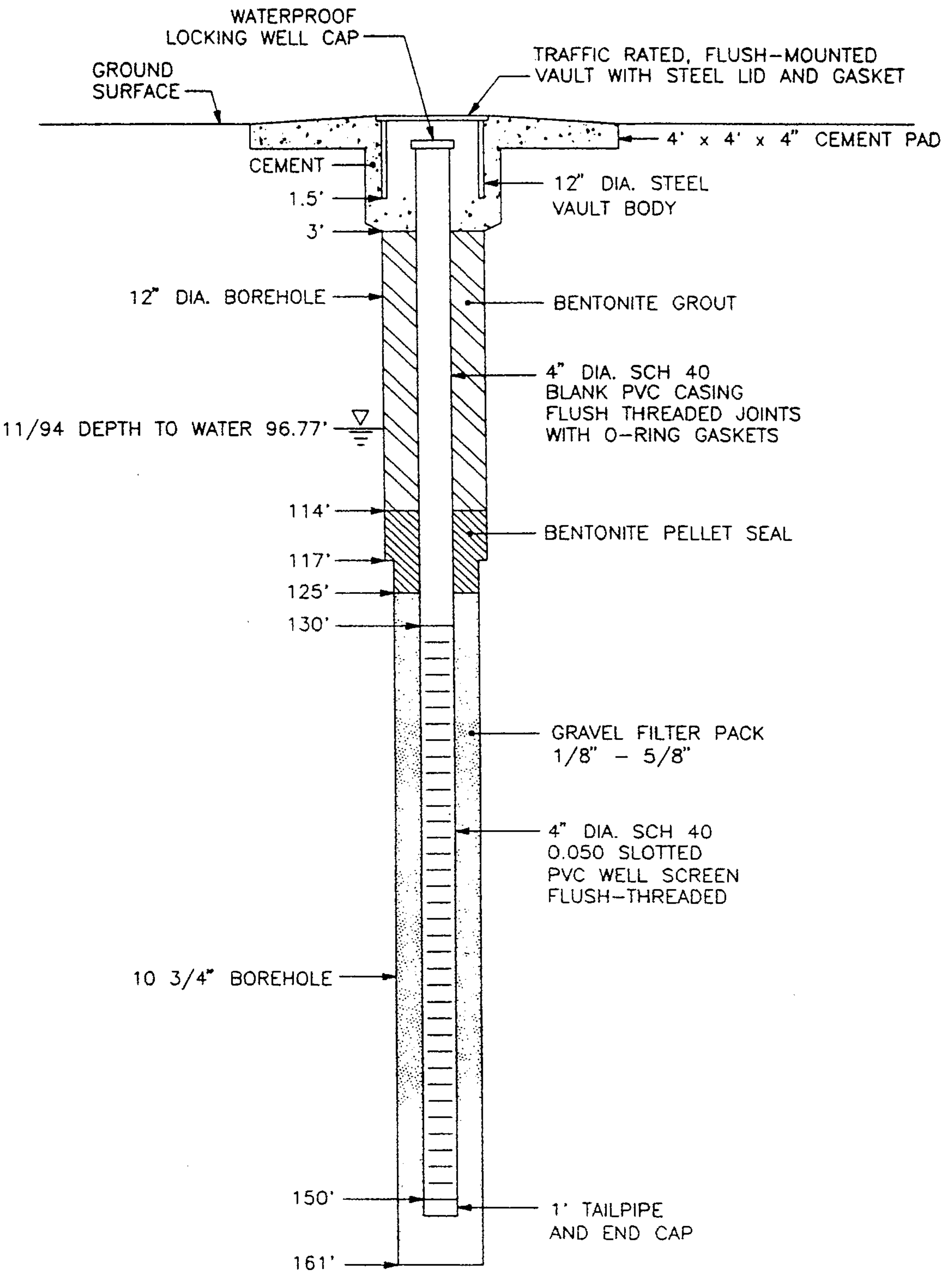
NOT TO SCALE

SOUTH PASS RESOURCES, INC.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-05	2/15/95		M.O'M.

MONITOR WELL MMW-7
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C3

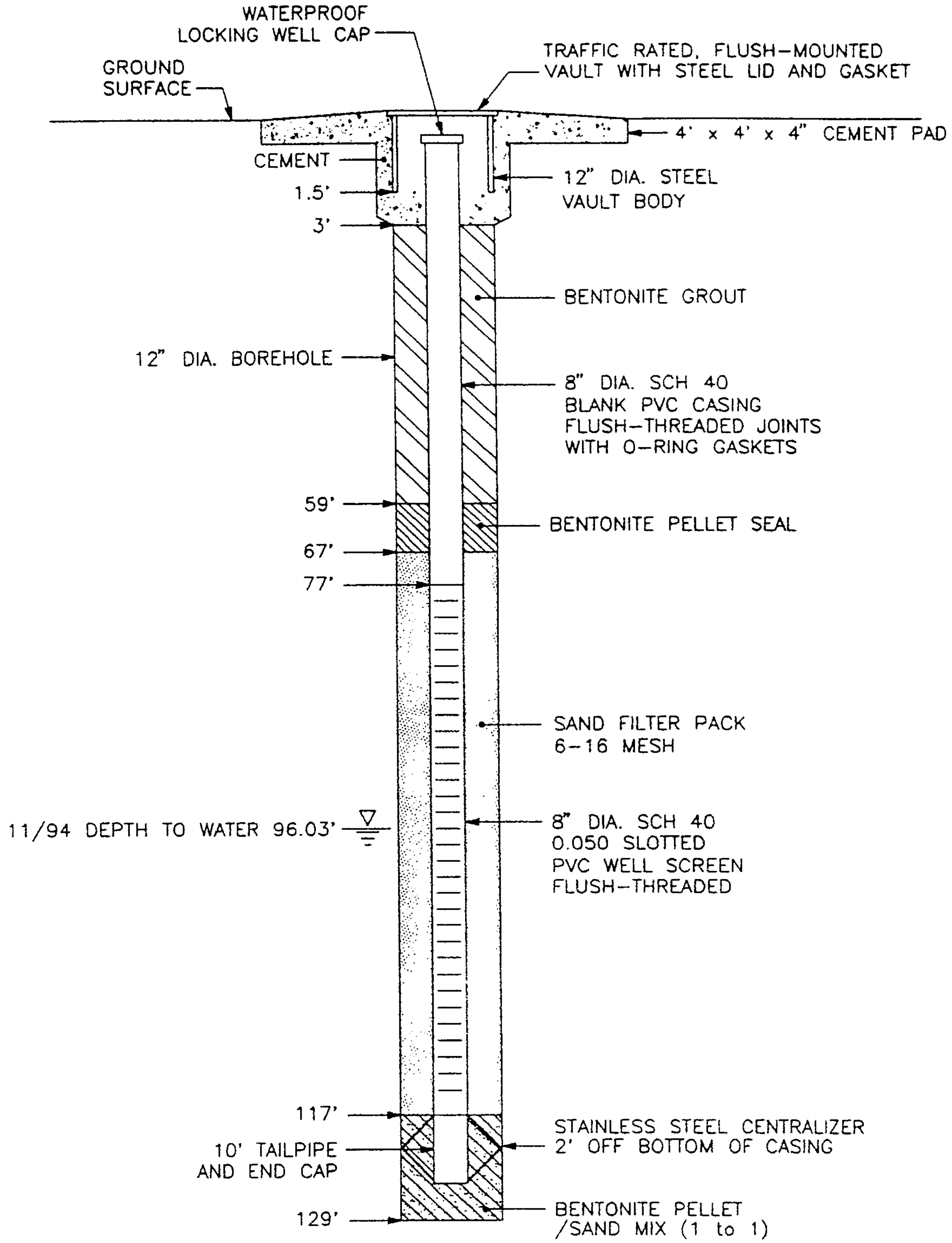


SCHEMATIC OF WELL CONSTRUCTION

NOT TO SCALE

SOUTH PASS RESOURCES, INC.				MONITOR WELL MMW-8A Molycorp, Inc. Questa, New Mexico	FIGURE: C4
PROJECT No.: 001-05	DATE: 2/15/95	AUTHOR:	DRAWN BY: M.O'M.		

MMW-8B



SCHEMATIC OF WELL CONSTRUCTION

NOT TO SCALE

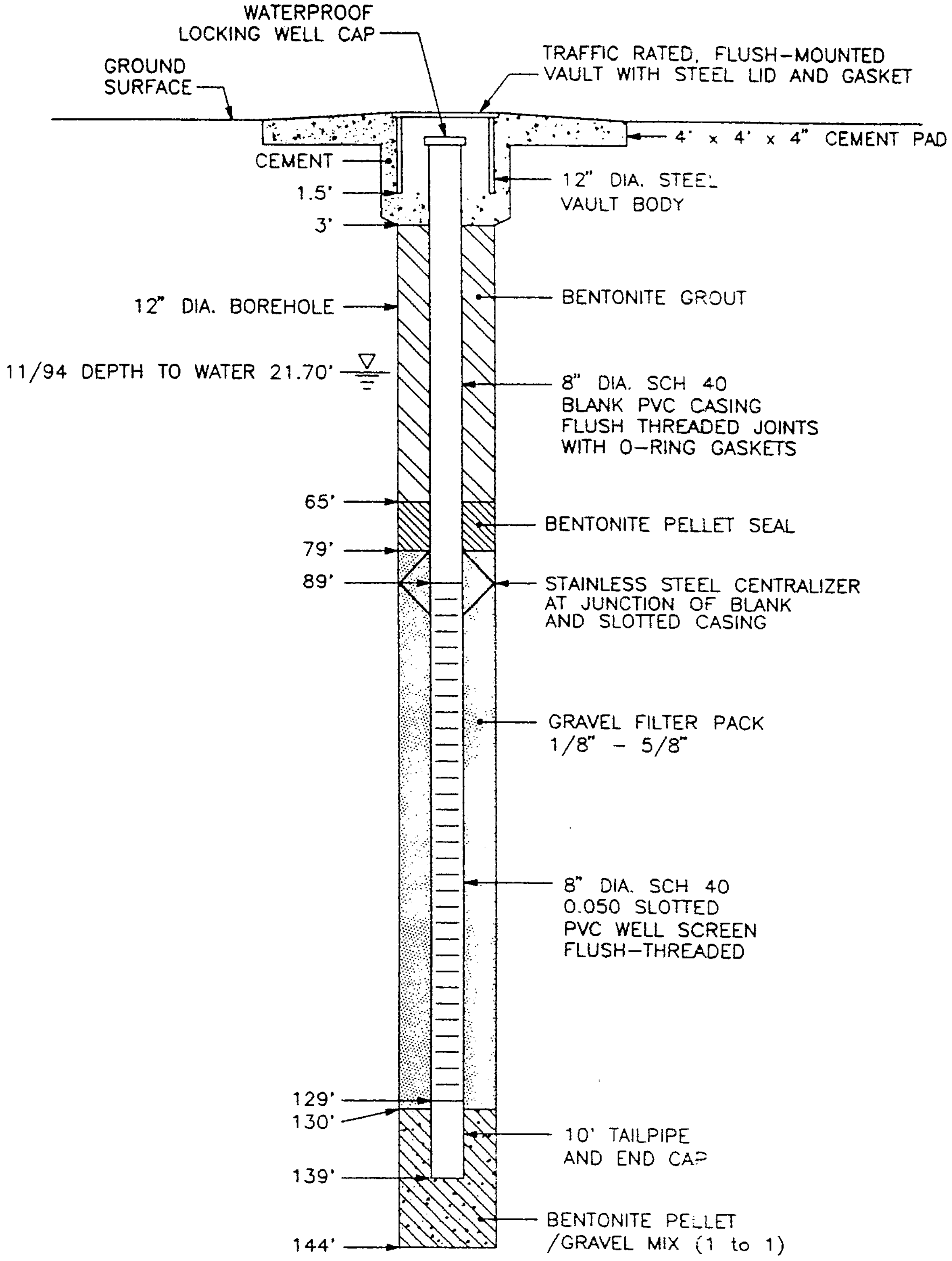
SOUTH PASS RESOURCES, INC.

PROJECT No.: 001-05
DATE: 2/15/95
AUTHOR:
DRAWN BY: M.O'M.

MONITOR WELL MMW-8B
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C5

MMW-10A



SCHEMATIC OF WELL CONSTRUCTION

NOT TO SCALE

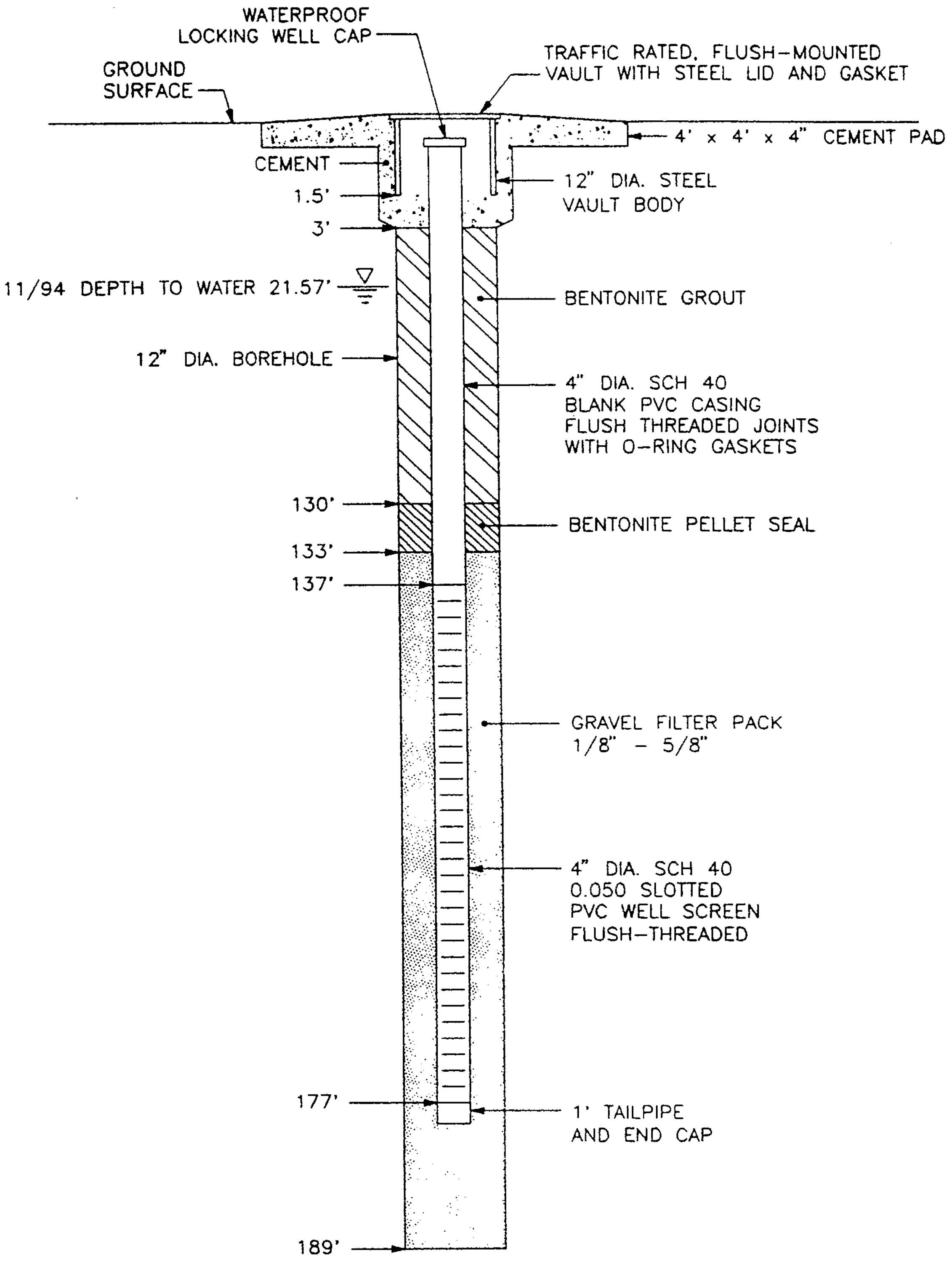
SOUTH PASS RESOURCES, INC.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-05	2/15/95		M.O'M.

MONITOR WELL MMW-10A
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C6

MMW-10B



SCHEMATIC OF WELL CONSTRUCTION

NOT TO SCALE

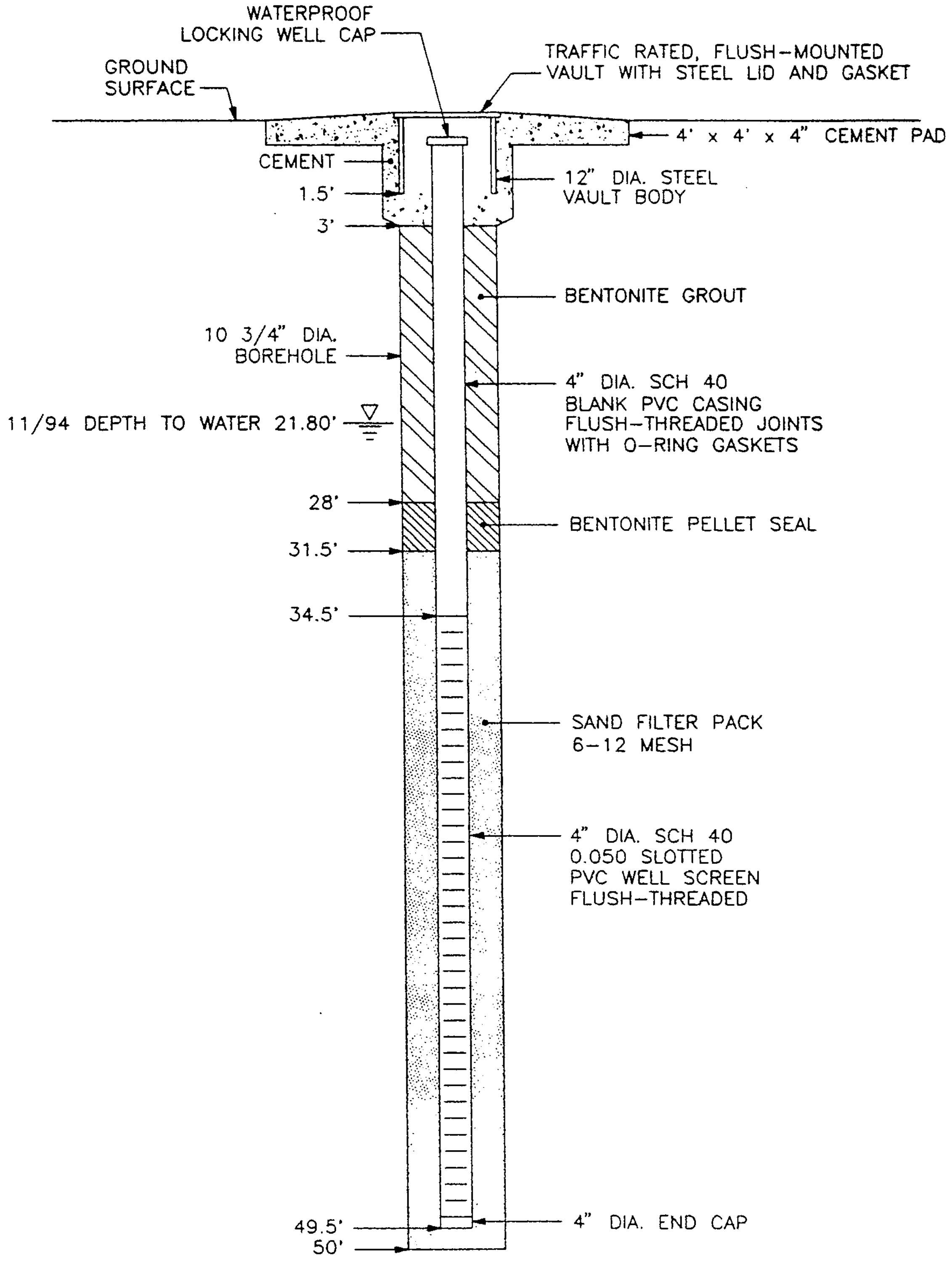
SOUTH PASS RESOURCES, INC.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-05	2/15/95		M.O'M.

MONITOR WELL MMW-10B
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C7

MMW-10C



SCHEMATIC OF WELL CONSTRUCTION

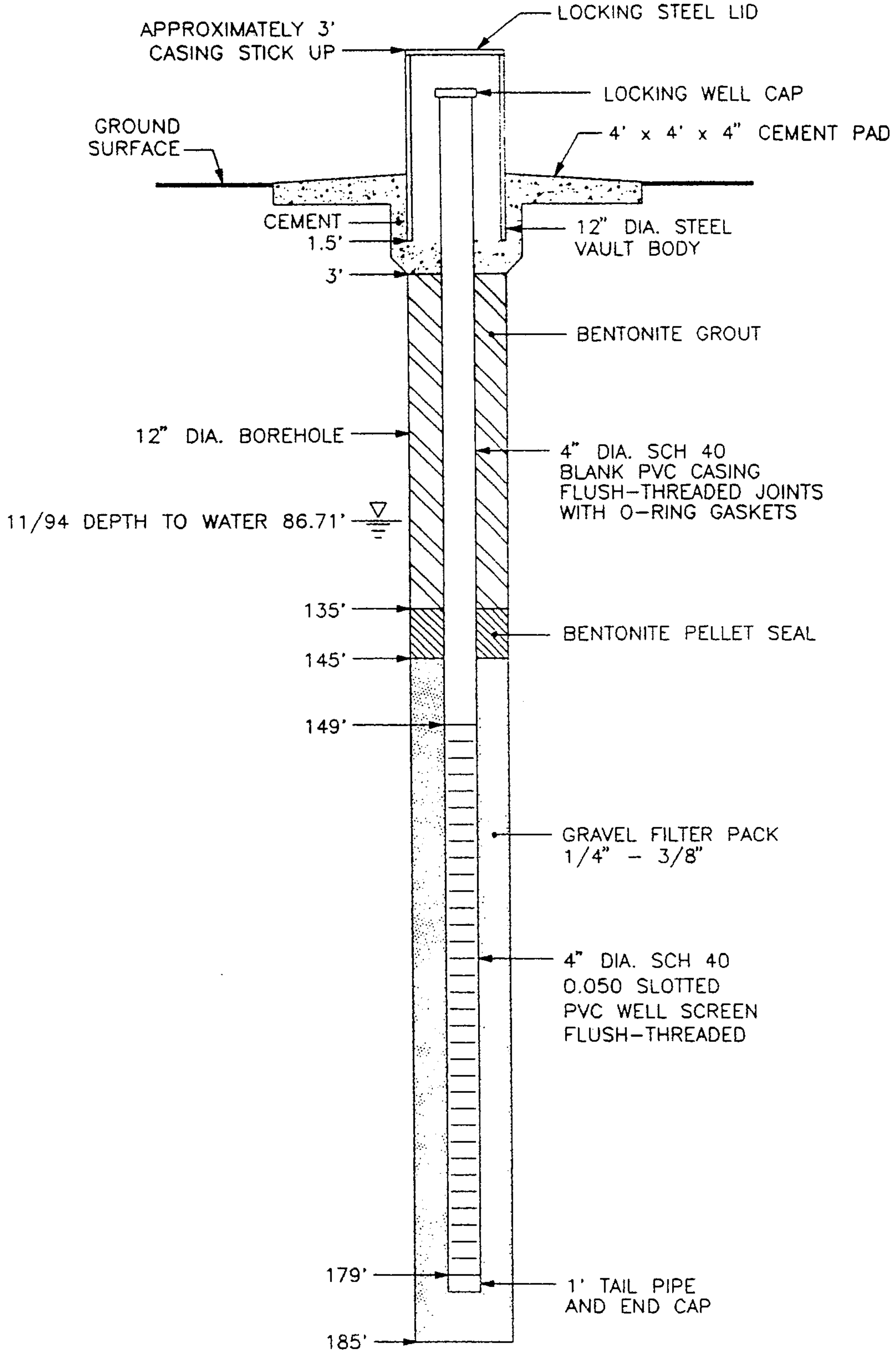
NOT TO SCALE

SOUTH PASS RESOURCES, INC.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-05	2/15/95		M.O'M.

MONITOR WELL MMW-10C
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C8



SCHEMATIC OF WELL CONSTRUCTION

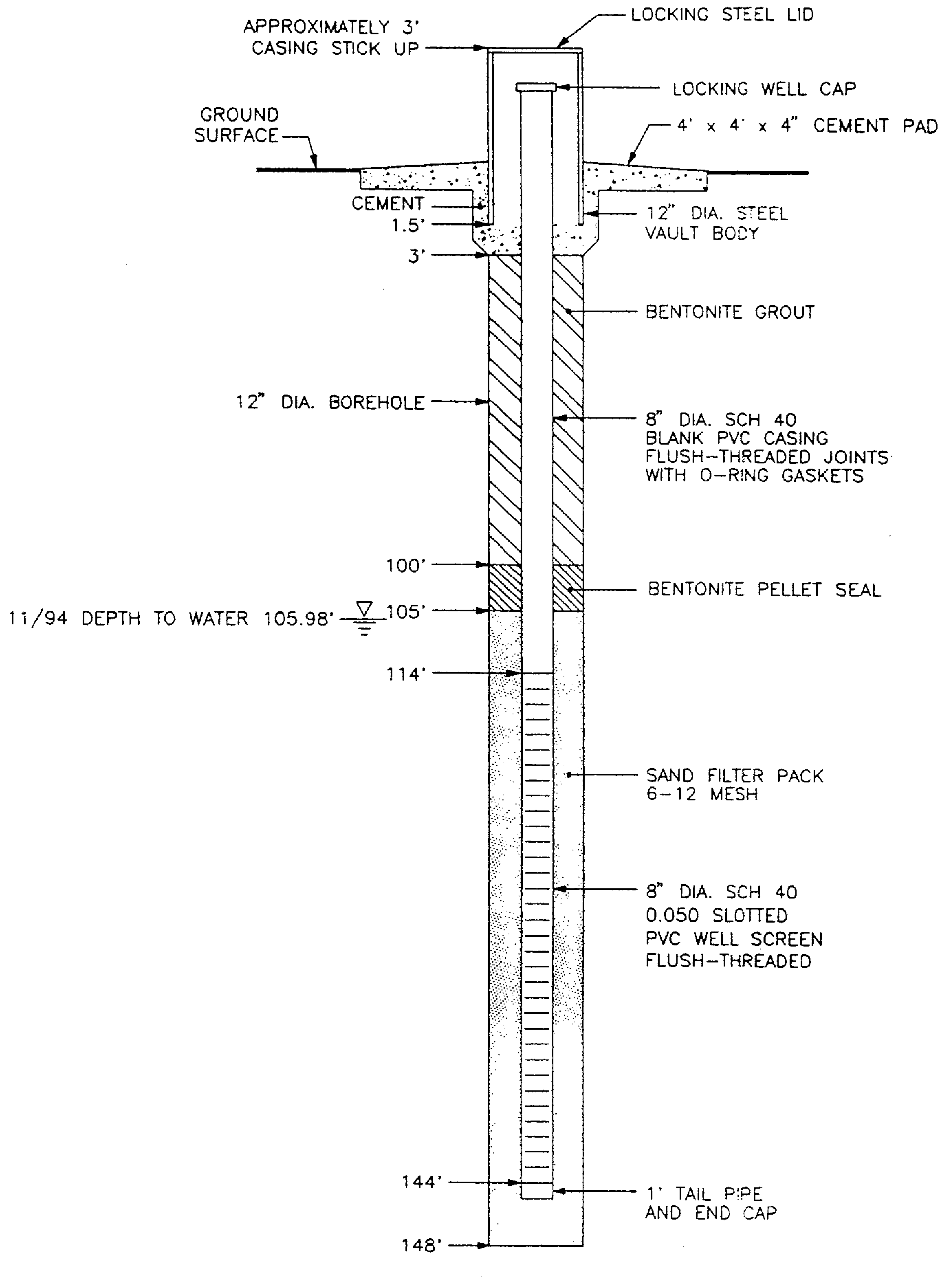
NOT TO SCALE

SOUTH PASS RESOURCES, Inc.

PROJECT No.: 001-05
DATE: 2/15/95
AUTHOR:
DRAWN BY: M.O'M.

MONITOR WELL MMW-11
Molycorp, Inc.
Questa, New Mexico

FIGURE: C9

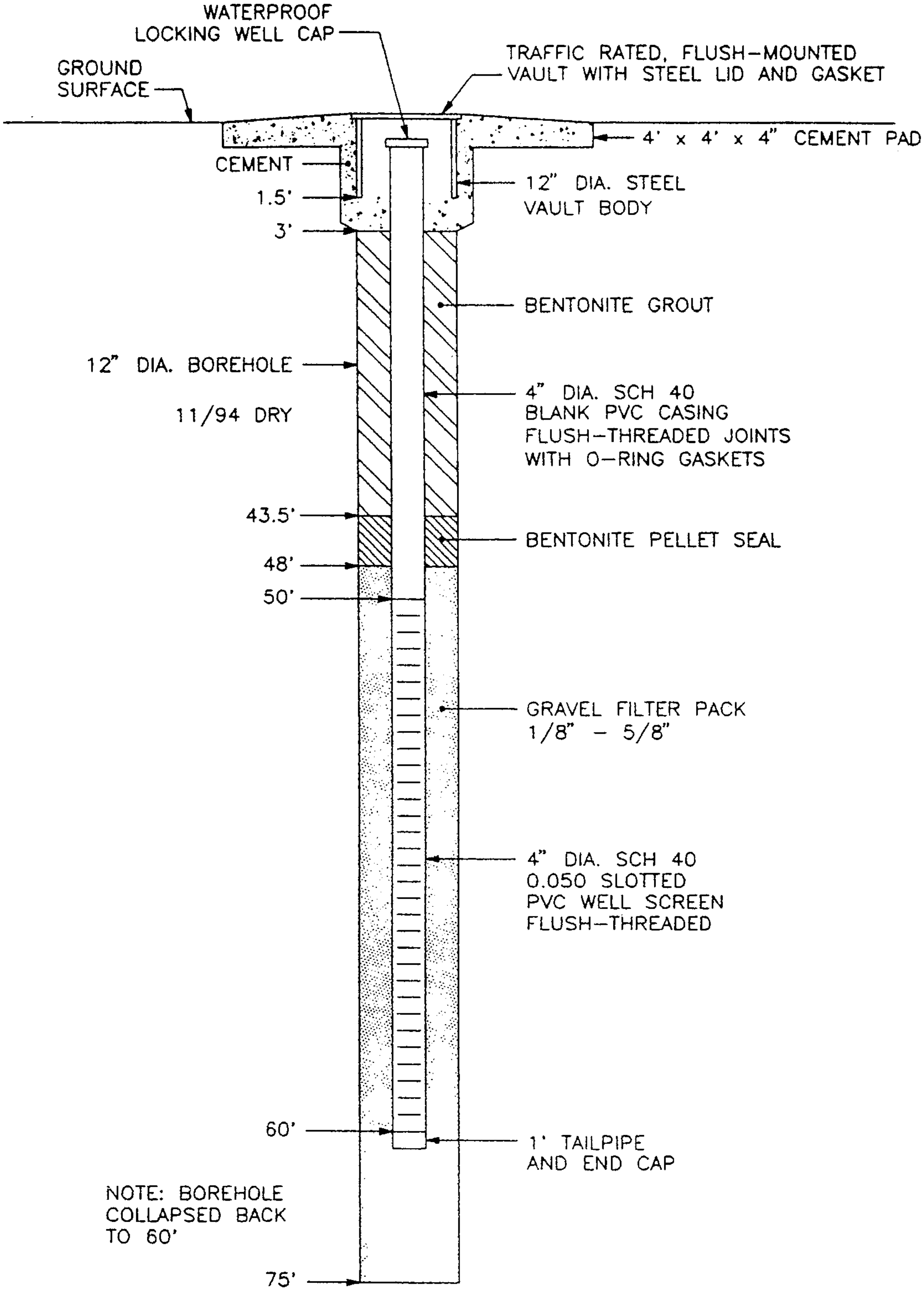


SCHEMATIC OF WELL CONSTRUCTION

NOT TO SCALE

SOUTH PASS RESOURCES, Inc.				MONITOR WELL MMW-13 Molycorp, Inc. Questa, New Mexico	FIGURE: C10
PROJECT No.: 001-05	DATE: 2/15/95	AUTHOR:	DRAWN BY: M.O'M.		

MMW-14



SCHEMATIC OF WELL CONSTRUCTION

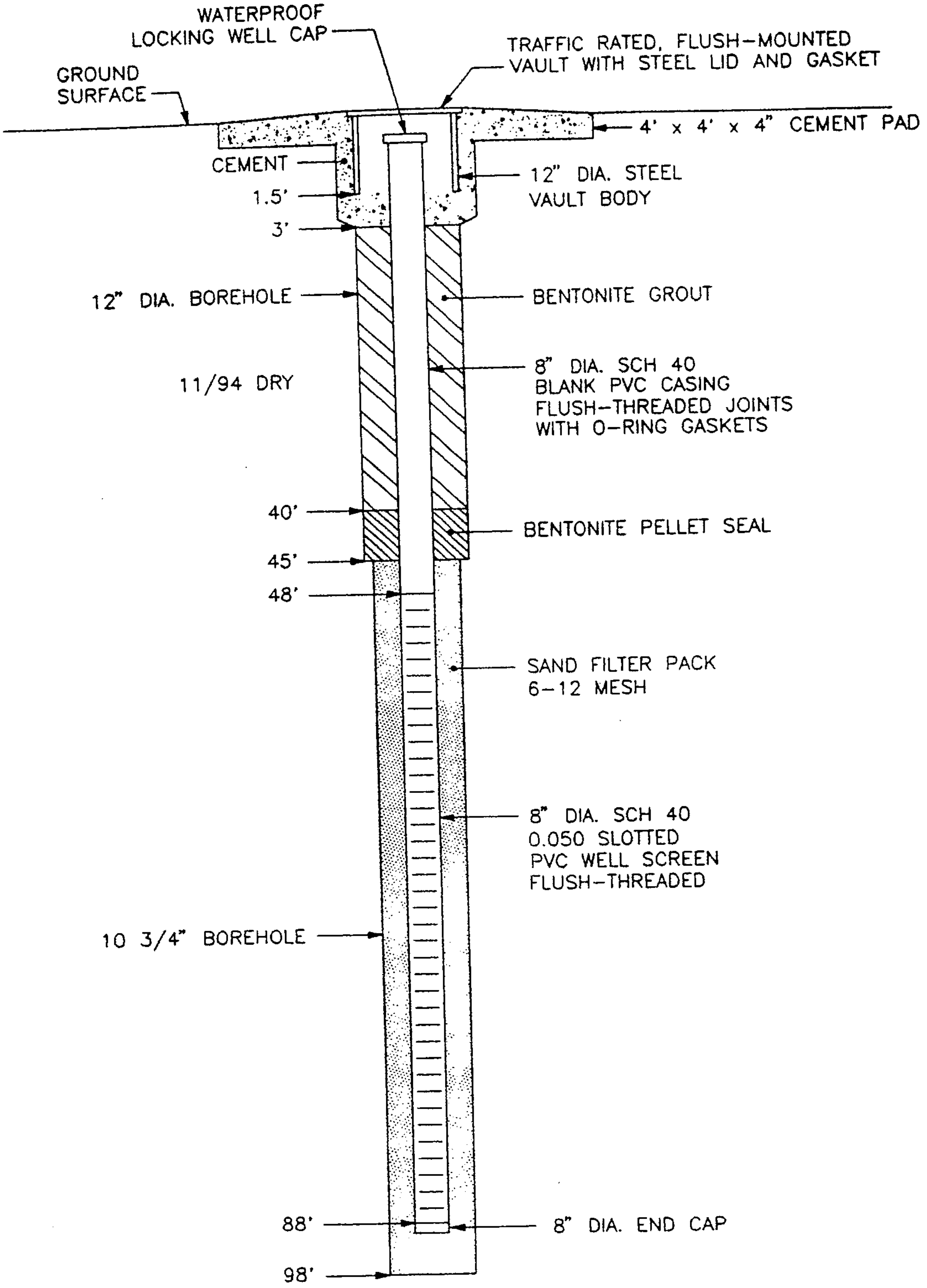
NOT TO SCALE

SOUTH PASS RESOURCES, INC.

PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-05	2/15/95		M.O'M.

MONITOR WELL MMW-14
Molycorp, Inc.
Questa, New Mexico

FIGURE:
C11

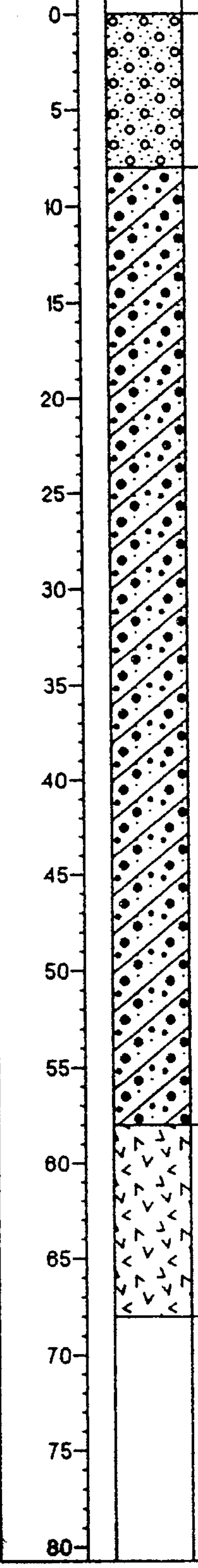


SCHEMATIC OF WELL CONSTRUCTION

NOT TO SCALE

SOUTH PASS RESOURCES, INC.				MONITOR WELL MMW-16 Molycorp, Inc. Questa, New Mexico	FIGURE: C12
PROJECT No.: 001-05	DATE: 2/15/95	AUTHOR:	DRAWN BY: M.O'M.		

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
						Fill	Fill fragments of andesite and rhyolite.
						GC	BROWN SANDY CLAYEY GRAVEL clasts of andesite and rhyolite matrix. Matrix sandy clay to clayey sand. andesite boulder associated with coarse gravel
						Rock	DARK GRAY ANDESITE bedrock contact, some flow banding and tan to gray rhyolite.
							Boring terminated at 68.0 feet and monitor well installed.



DRILL DATE
START: 8/27/94 FINISH: 8/28/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

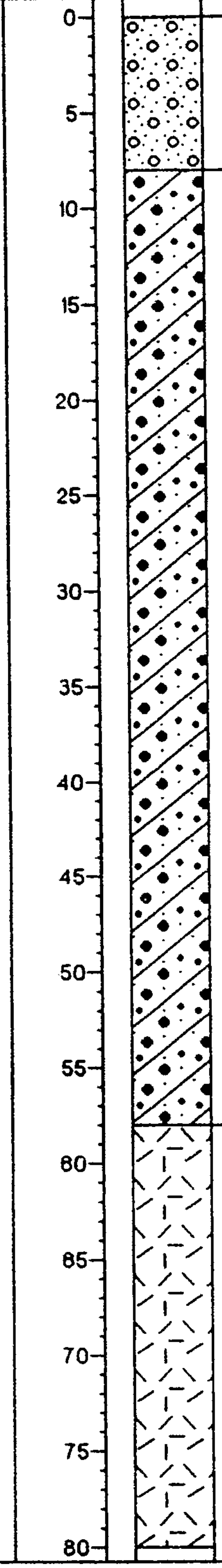
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-2
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C13



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
						Fill	Fill fragments of andesite and phyrite.
						GC	BROWN SANDY CLAYEY GRAVEL clasts of andesite and rhyolite matrix. Matrix sandy clay to clayey sand. andesite boulder associated with coarse gravel
						Rock	DARK GRAY ANDESITE bedrock contact, some flow banding and tan to gray rhyolite. andesiste pyritic

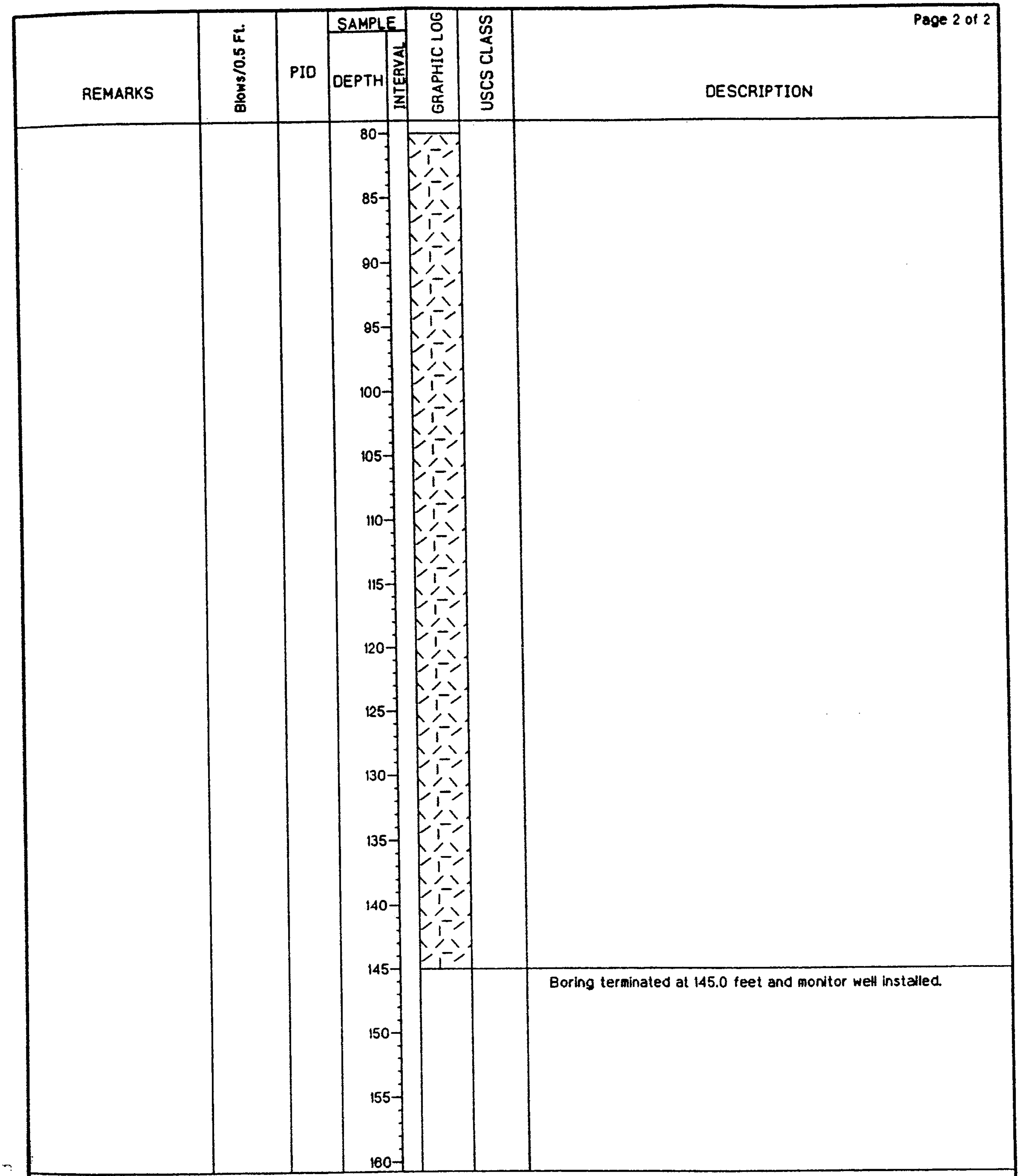
DRILL DATE
START: 8/24/94 FINISH: 8/26/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05
DATE 1/16/95

LOG OF BORING No. MMW-3
Molycorp, Inc.
Questa, New Mexico

FIGURE No.
C14



Boring terminated at 145.0 feet and monitor well installed.

DRILL DATE
START: 8/24/94 FINISH: 8/26/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

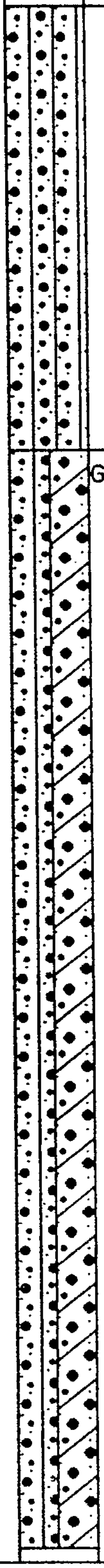
SOUTH PASS RESOURCES, Inc.

PROJECT No.	DATE
001-05	1/16/95

LOG OF BORING No. MMW-3
Molycorp, Inc.
Questa, New Mexico

FIGURE No.
C14a

Page 1 of 3

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			GM	**Fill or Colluvium** angular fragments of yellow, gray and red rhyolite with minor amounts of dark glassy porphyritic volcanics.
			5				
			10				
			15				
			20				
			25			GM/GC	BROWN CLAYEY GRAVEL clasts of andesite, rhyolite, welded tuff, and dark volcanics, subangular to subrounded. Matrix of silt, clay and sand.
			30				
			35				
			40				
			45				larger chips, cobbles and boulders
Moisture content pick up at 50'-55', sticy clays			50				clay content increasing in matrix, strong yellow color to clay
			55				
			60				
			65				
			70				
			75				more andesite clasts
			80				

DRILL DATE

START: 8/10/94 FINISH: 8/13/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-7
Molycorp, Inc.
Questa, New Mexico

FIGURE No. **C15**

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			80				
Borehole water is < 1 gpm			85			Rock	**GRAY ANDESITE** bedrock contact, porphyritic andesite, pyrite and calcite vein fill.
			90				
Borehole water 1-2 gpm, unaltered pyrite in fractures			95				
			100				
			105				
			110				
			115				
			120				
			125				
			130				
			135				
			140				
			145				
			150				
			155				
			160				

DRILL DATE
START: 8/10/94 FINISH: 8/13/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-7
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C15a

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			160				
							Boring terminated at 161.0 feet and monitor well installed.
			165				
			170				
			175				
			180				
			185				
			190				
			195				
			200				
			205				
			210				
			215				
			220				
			225				
			230				
			235				
			240				

DRILL DATE
START: 8/10/94 FINISH: 8/13/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

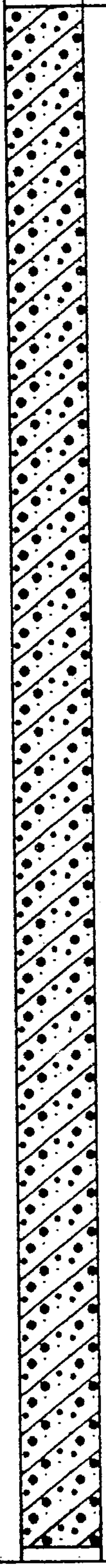
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-7

Molycorp, Inc.
Questa, New Mexico

FIGURE No. **C15b**

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			GC	SANDY CLAYEY GRAVEL clasts of dark colored andesite, quartz monzonite in a yellow-tan clayey sand to sandy clay.
			5				
			10				
			15				
			20				
			25				
			30				more cobbly material 26 to 36 feet
			35				weld tuff clasts appear at 36 feet
			40				
			45				
			50				
			55				
			60				matrix of sand and clay changes to brown color
			65				
			70				
			75				matrix of sand and clay orange color
			80				

DRILL DATE
START: 8/13/94 FINISH: 8/17/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

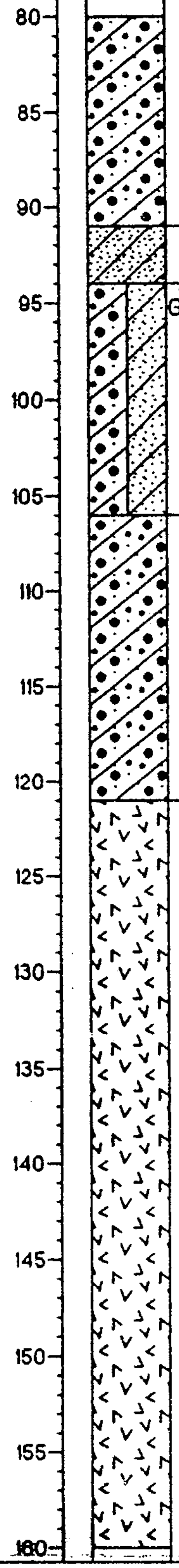
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-8A
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C16



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	USCS CLASS	DESCRIPTION
					SC	**YELLOW/TAN CLAYEY SAND** clasts of andesite, rhyolite and quartz, subangular to subrounded.
					GC/SC	**CLAYEY SANDY GRAVEL** coarse gravel, clasts of andesite and rhyolite, matrix of yellow to tan clayey sand. gravel alternating with layers of clayey sand
					GC	**CLAYEY SANDY GRAVEL** as above.
					Rock	**GRAY ANDESITE** bedrock contact, porphyritic andesite. light brown to tan rhyolite and dark gray to tan andesite fragments predominately andesite below 141 feet

DRILL DATE
START: 8/13/94 FINISH: 8/17/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.
PROJECT No. 001-05
DATE 1/16/95

LOG OF BORING No. MMW-8A
Molycorp, Inc.
Questa, New Mexico

FIGURE No.
C16a

Page 3 of 3

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			160				
							Boring terminated at 161.0 feet and monitor well installed.
			165				
			170				
			175				
			180				
			185				
			190				
			195				
			200				
			205				
			210				
			215				
			220				
			225				
			230				
			235				
			240				

DRILL DATE
START: 8/13/94 FINISH: 8/17/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

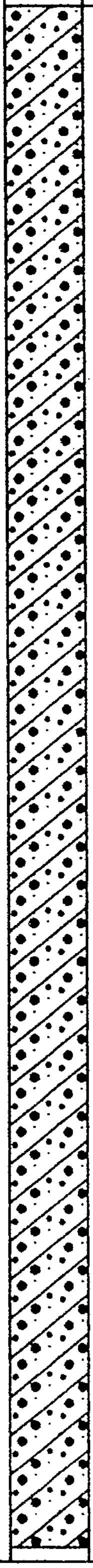
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-8A

Molycorp, Inc.
Questa, New Mexico

FIGURE No. **C16b**

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			GC	SANDY CLAYEY GRAVEL clasts of dark colored andesite, quartz monzonite matrix: yellow-tan clayey sand to sandy clay.
			5				
			10				
			15				
			20				
			25				
			30				more cobbly material 26 to 38 feet
			35				weld tuff clasts appear at 38 feet
			40				
			45				
			50				
			55				matrix of sand and clay changes to brown color
			60				
			65				
			70				
			75				matrix of sand and clay orange color
			80				

DRILL DATE
START: 8/22/94 FINISH: 8/24/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

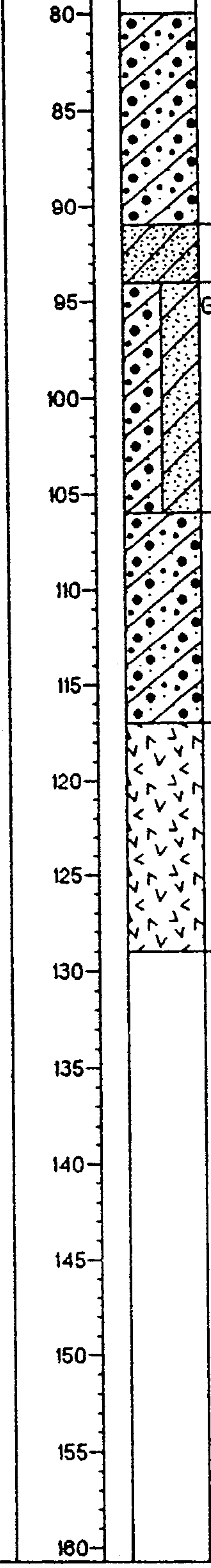
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-8B

Molycorp, Inc.
Questa, New Mexico

FIGURE No. C17



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
						SC	YELLOW/TAN CLAYEY SAND clasts of andesite, rhyolite and quartz, subangular to subrounded.
						GC/SC	CLAYEY SANDY GRAVEL coarse gravel, clasts of andesite and rhyolite, matrix of yellow to tan clayey sand. gravel alternating with layers of clayey sand
						GC	CLAYEY SANDY GRAVEL as above.
						Rock	GRAY ANDESITE bedrock contact, porphyritic andesite.
							Boring terminated at 129.0 feet and monitor well installed.

DRILL DATE
START: 8/22/94 FINISH: 8/24/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

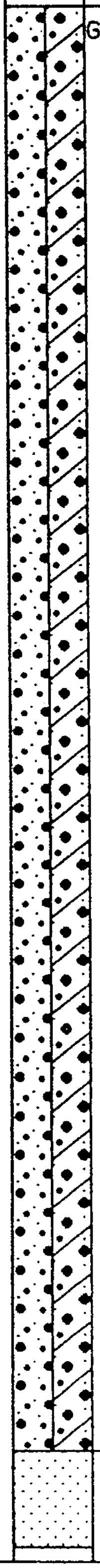
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-8B
Molycorp, Inc.
Questa, New Mexico

FIGURE No.
C17a

Page 1 of 2

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			GW/GC	CLAYEY SAND GRAVEL angular fragments of andesite dominate to 55 feet. Rocks are pyrite with iron oxide coatings. Dark brown matrix of clay and sand.
			5				
			10				
			15				
			20				
Free water <1 gpm			25				
			30				
			35				
			40				
			45				clay more abundant below 45 feet
			50				
			55				quartz monzonite, aplite and rhyolite more abundant than andesite 55'-75'
			60				
			65				
			70				
Borehole water 4-5 gpm			75			SP	BROWN GRAVELLY SAND fine to coarse gravel, quartz monzonite, quartz, aplite and andseite. Clay less than 1%.
			80				

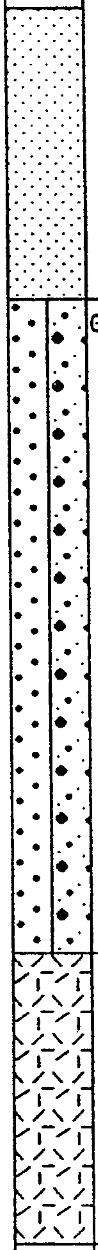
DRILL DATE
START: 7/17/94 FINISH: 7/20/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05
DATE 1/16/95

LOG OF BORING No. MMW-10A
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C18



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			80				
			85				
			90				
			95			GP/GW	BROWN SANDY GRAVEL well rounded clasts of of quartz monzonite, granite, quartz and rhyolite.
			100				
			105				105'-115' feet, thin interbedded clay layers (less than 0.5 foot)
Borehole water 70-100 gpm			110				
			115				
			120				
			125				
			130			Rock	LIGHT GRAY QUARTZ MONZONITE bedrock contact, medium crystalline rock, dominantly white and gray feldspar with 10% quartz and less than 50% mafics.
			135				
			140				
			145				Boring terminated at 144.0 feet and monitor well installed.
			150				
			155				
			160				

DRILL DATE
START: 7/17/94 FINISH: 7/20/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

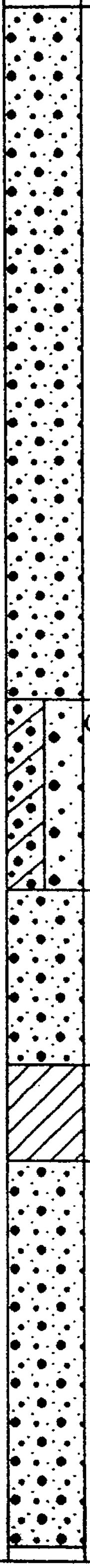
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-10A
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C18a



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			GW	SANDY GRAVEL angular fragments of andesite with some rhyolite. Much iron staining on clasts. Brown matrix of sand.
			5				
			10				
			15				
			20				
			25				
Borehole water 2-3 gpm			30				
			35				
						GC/GW	DARK BROWN-BLACK CLAYEY GRAVEL
			40				
Borehole water 3-5 gpm			45				
						GW	SANDY GRAVEL angular fragmnets of rhyolite and quartz monzonite.
			50				
Borehole water 2-3 gpm							
			55			CL	TAN TO YELLOW CLAY gypsum present.
			60			GW	SANDY GRAVEL angular fragments of quartz monzonite, rhyolite and pegmatite. Iron oxide coatings, pyrite present. Matrix of brown sand.
			65				
			70				
			75				
			80				

DRILL DATE
START: 7/11/94 FINISH: 7/14/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary Casing Drive SAMPLE TYPE: Cuttings

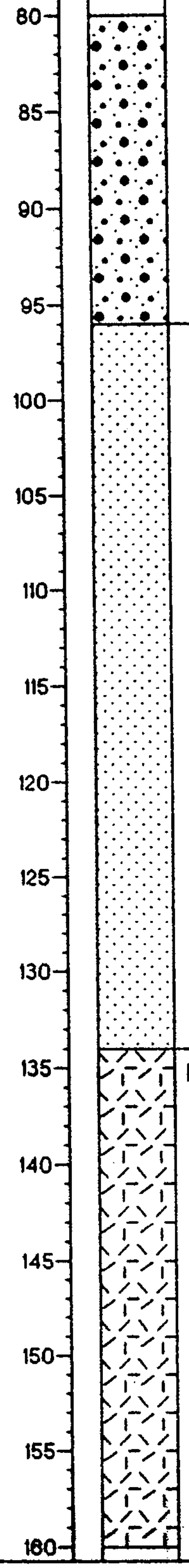
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-10B
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C19



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			80				
			85				
			90				buried log (laying horizontal) present
			95			SP	BROWN-GRAY GRAVELLY SAND medium-grained, well rounded, 90% quartz. Well rounded clasts of rhyolite, pegmatite, andesite, quartz.
			100				
			105				
			110				gravelly sand alternating with medium-grained sand
			115				
			120				black organic material at 121-122 feet
			125				
			130				
			135			Rock	QUARTZ MONZONITE bedrock contact, pyritic, fractured.
			140				
			145				
			150				
			155				
			160				

DRILL DATE
START: 7/11/94 FINISH: 7/14/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-10B
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C19a

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REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			160		▨		
			165		▨		
			170		▨		
			175		▨		
			180		▨		
			185		▨		
			190				Boring terminated at 189.0 feet and monitor well installed.
			195				
			200				
			205				
			210				
			215				
			220				
			225				
			230				
			235				
			240				

DRILL DATE
START: 7/11/94 FINISH: 7/14/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

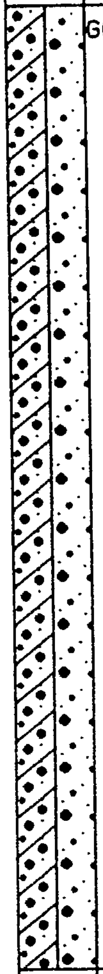
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-10B
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C19b

Page 1 of 1

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			GC/GM	CLAYEY SANDY GRAVEL angular fragments of andesite dominate to 55 feet
			5				
			10				
			15				
			20				
			25				
			30				
			35				
			40				
			45				
			50				Boring terminated at 50.0 feet and monitor well installed.
			55				
			60				
			65				
			70				
			75				
			80				

DRILL DATE
START: 7/25/94 FINISH: 7/26/94

LOGGED By: W. Opfel

DRILL RIG: Air Rotary/ Casing Drive

SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-10C
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C20

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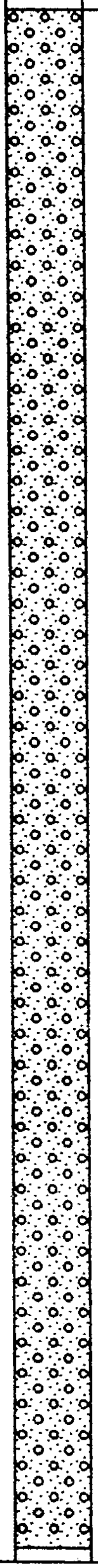
REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	 INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80			Fill	Fill angular fragments of andesite, quartz monzonite, aplite, and quartz. Iron oxide coatings, but pyrite on fresh surfaces, 15%-20% yellow clay matrix present.

DRILL DATE
START: 7/15/94 FINISH: 7/17/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

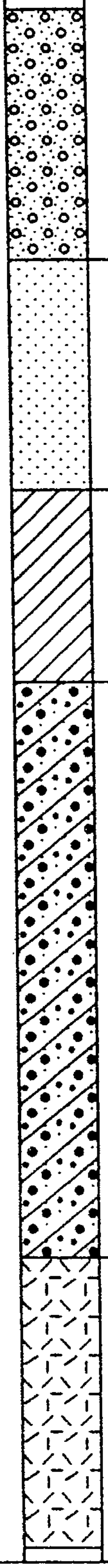
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-11
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C21



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	USCS CLASS	DESCRIPTION
increasing moisture content; no free water			80			
			85			
Borehole water 1-2 gpm			90		SP	**SANDY GRAVEL** clasts as above but rounded.
			95			
			100			
			105		CL	**GRAVELLY CLAY** clasts as above, clay content 75%
			110			
Borehole water 1 gpm			115		GC	**CLAYEY GRAVEL** clay content 10%-20%.
			120			
Borehole water 2-3 gpm			125			
			130			
			135			
Borehole water 2-4 gpm			140			
Borehole water 2-4 gpm			145		Rock	**QUARTZ MONZONITE** bedrock contact.
Borehole water 5-10 gpm			150			
			155			Cuttings to 165 feet, > 1/2 inch slight decrease in chip size below 165 feet. Fracture zone better developed above 165 feet.
			160			

DRILL DATE
START: 7/15/94 FINISH: 7/17/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

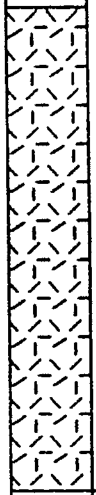
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-11
Molycorp, Inc.
Questa, New Mexico

FIGURE No. **C21a**

Page 3 of 3

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			160				
			165				
			170				
			175				
			180				
			185				Boring terminated at 185.0 feet and monitor well installed.
			190				
			195				
			200				
			205				
			210				
			215				
			220				
			225				
			230				
			235				
			240				

DRILL DATE

START: 7/15/94 FINISH: 7/17/94 LOGGED By: W. Opfel DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No: 001-05

DATE 1/16/95

LOG OF BORING No. MMW-11

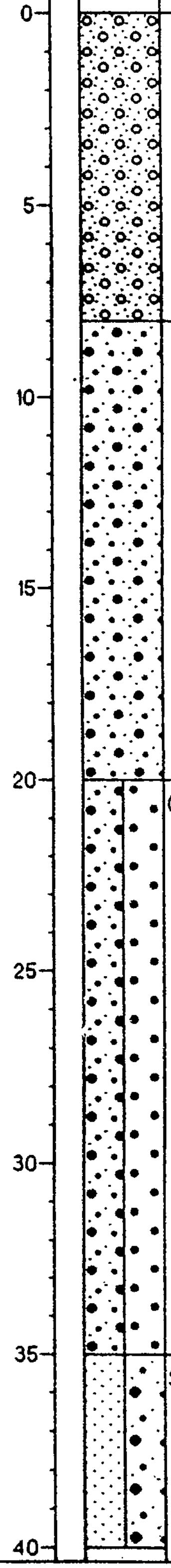
Molycorp, Inc.

Questa, New Mexico

FIGURE No. C21b

Page 1 of 4

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			Fill	Fill angular fragments of quartz monzonite, rhyolite diabase in a matrix of medium-brown silt to coarse-grained sand with wood fragments.
						GW	SANDY GRAVEL coarse gravel, cobbles, angular to subangular; clasts consist of quartz monzonite, rhyolite, and red-purple volcanic, diabase. Medium to dark brown matrix of fine- to coarse-grained sand, subangular to subrounded, less than 5% silt.
			20			GW/GP	SANDY GRAVEL fine and coarse gravel, fine gravel is subrounded; clasts consist of quartz monzonite, andesite, quartzite, and iron-stained rhyolite. Dark brown matrix of fine- to coarse-grained sand; subangular to subrounded quartz, feldspar and lithics.
			35			SP/GW	GRAVELLY SAND/SANDY GRAVEL fine to coarse gravel and cobbles; subangular to subrounded; clasts consist of gray-green andesite, rhyolite tuff, red sandstone and quartz monzonite. Medium brown sand matrix, medium- to coarse-grained subangular to subrounded.



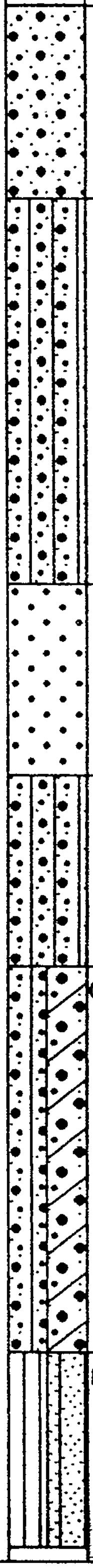
DRILL DATE
START: 8/1/94 FINISH: 8/9/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05
DATE 1/16/95

LOG OF BORING No. MMW-13
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C22



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			40			GW	SANDY GRAVEL fine and coarse gravel, cobbles and boulders, subangular to subrounded; clasts consist of andesite, aplite, purple volcanics, limonite/silica rock. Medium brown matrix of medium- to coarse-grained sand, subangular to subrounded.
			45			GM	Similar to above, sand matrix is fine- to coarse-grained, 5%-10% silt and clay.
			50				
			55			GP	SANDY GRAVEL as above, cobbles and boulders more common, no silt or clay.
			60			GM	SANDY GRAVEL as above, more iron-stained silica rock.
			65			GM/GC	SANDY GRAVEL same as above, clay and silt increases to 20%-30% in matrix.
			70				
			75			ML/SM	DARK BROWN SILTY SAND/SANDY SILT fine- to coarse-grained; clasts consist of quartz and lithics, subangular to subrounded.
			80				

DRILL DATE
START: 8/1/94 FINISH: 8/9/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

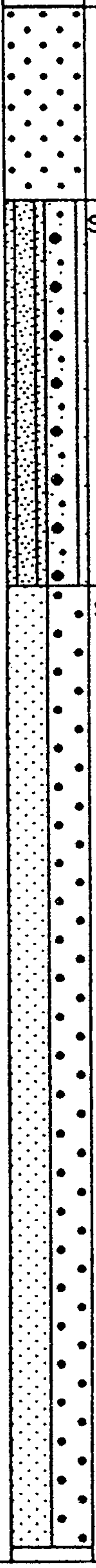
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-13
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C22a



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			80			GP	BROWN SANDY GRAVEL fine to coarse gravel, cobbles and boulders, subangular to subrounded; clasts consist of quartz monzonite, purple and green volcanics, iron-stained silica rock. Medium to dark brown matrix of fine- to coarse-grained sand, subangular to subrounded.
			85			SM/GM	SILTY SAND AND SILTY SANDY GRAVEL fine to coarse gravel, cobbles and boulders, subangular to subrounded; clasts consist of quartz monzonite, andesite, purple volcanics. Medium brown matrix of fine to coarse-grained sand; clasts of quartz and lithics, 5%-10% silt.
			90				
			95			SP/GP	GRAVELLY SAND TO SANDY GRAVEL fine and coarse gravel, cobbles and scattered boulders, subangular to subrounded; clasts consist of predominately quartz monzonite with minor amounts of volcanic rock and altered volcanic rock. Light gray matrix of medium- to coarse-grained sand, subrounded, 70% quartz and 30% feldspar and lithics.
			100				
			105				
			110				
			115				
			120				

DRILL DATE
START: 8/1/94 FINISH: 8/9/94

LOGGED By: J.Kepper

DRILL RIG: Air Rotary/ Casing Drive

SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

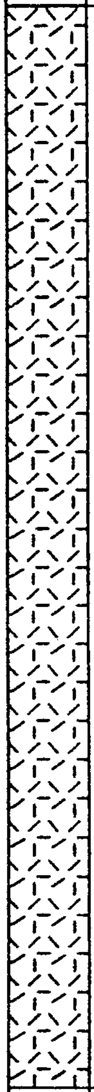
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-13
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C22b

REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			120			Rock	**QUARTZ MONZONITE** Bedrock Contact at 120 feet, 120-125 feet; large 1 to 1 1/2 inch fragments, unstained quartz monzonite, probably upper fracture zone. Chip size decreases with depth.
			125				
			130				light gray coarsely crystalized rock, predominately feldspar with minor quartz and mafic minerals.
			135				
			140				
			145				
							Boring terminated at 148 feet and ground-water monitor well installed.
			150				
			155				
			160				



DRILL DATE
START: 8/1/94 FINISH: 8/9/94

LOGGED By: J.Kepper

DRILL RIG: Air Rotary/ Casing Drive

SAMPLE TYPE: Cuttings

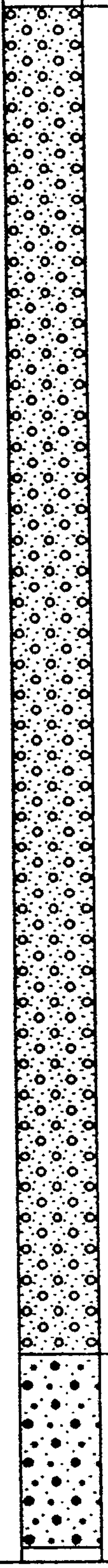
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-13
Molycorp, Inc.
Questa, New Mexico

FIGURE No.
C22c



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0			Fill	Waste Dump Material angular fragments of quartz, aplite and andesite diabase mixed with metal, asphalt wrappings, wire and wood.
			5				
			10				
			15				
			20				
			25				
			30				25 to 35 feet: 20%-30% clay probably waste rock used to fill depression behind berm.
			35			GW	SANDY GRAVEL fine to coarse gravel, cobbles (1 1/2" chips), angular to rounded; clasts consist of granite, diabase and mafic rock. Medium brown matrix of very fine- to coarse-grained sand, subangular to subrounded.
			40				

DRILL DATE
START: 7/30/94 FINISH: 7/31/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

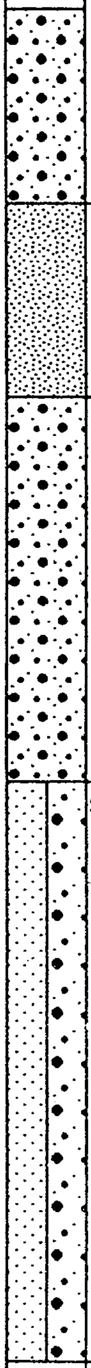
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-14
Molycorp, Inc.
Questa, New Mexico

FIGURE No. **C23**



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			40				
			45			SW	DARK BROWN SILTY GRAVELLY SAND fine- to coarse-grained, subangular to subrounded grains. Gravel is fine to coarse, rounded; clasts consist of granitic aplite and andesite, much iron-staining, 10%-15% silt.
			50			GW	SANDY GRAVEL coarse gravel and cobbles; angular to subrounded; clasts consist of granite, andesite, mafic rock and quartzite. Light gray matrix of fine- to coarse-grained sand, angular to subrounded; clasts of quartz, lithics; large (3") wood fragments.
			55				
			60			SP/GW	GRAVELLY SAND TO SANDY GRAVEL fine gravel, subrounded; clasts consist of granite, red sandstone and andesite. Light gray matrix of coarse-grained sand, 70% quartz.
			65				
			70				67 to 75 feet: no return rig action indicates boulders and gravel
			75				Boring terminated at 75.0 feet and monitor well installed.
			80				

DRILL DATE
START: 7/30/94 FINISH: 7/31/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

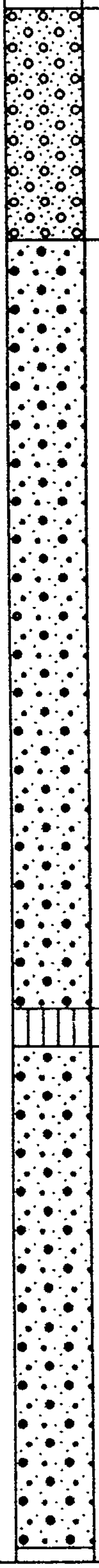
PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-14
Molycorp, Inc.
Questa, New Mexico

FIGURE No. **C23a**

Page 1 of 3



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			0 5			Fill	Fill angular fragments of aplite and andesite in a gray-brown sand matrix.
			10			GW	SANDY GRAVEL fine to coarse gravel, subangular to subrounded; clasts consist of granite, minor andesite, diabase and mafic rock. Medium brown matrix of fine- to coarse-grained sand, subangular to subrounded; clasts consist of quartz, feldspar and lithics.
			15 20 25				as above, clay and limnoite altered clasts more common, rare wood fragments
							DARK BROWN SANDY SILT (ML)
			30 35 40			GW	SANDY GRAVEL fine to coarse gravel; subangular to subrounded; strongly cemented by black limonite; clasts consist of aplite, granite, altered rock. Clasts are pyritic. Dark brown matrix of fine- to medium-grained sand, subangular to subrounded; clasts of quartz feldspar and lithics. Similar to 6-16' interval but larger fragments indicate cobble/boulder zone.

DRILL DATE
START: 7/28/94 FINISH: 7/28/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

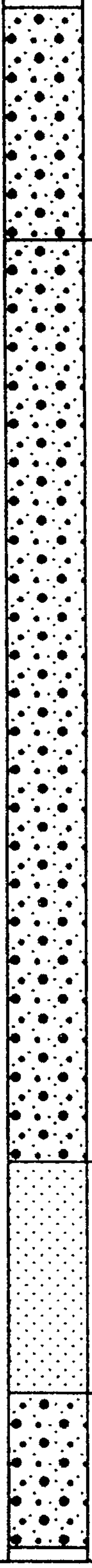
SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-16
Molycorp, Inc.
Questa, New Mexico

FIGURE No.
C24

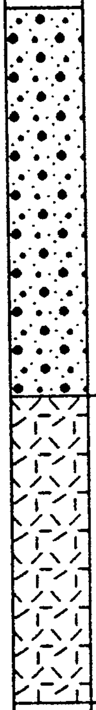
REMARKS	Blows/0.5 Ft.	PID	SAMPLE		GRAPHIC LOG	USCS CLASS	DESCRIPTION
			DEPTH	INTERVAL			
			40				
			45				
						GW	SANDY GRAVEL fine to coarse gravel, cobbles and boulders (large 1"-2" fragments), subangular to subrounded; clasts consist of aplite, granite, porphyrite andesite, altered rock. Medium brown matrix of fine- to coarse-grained sand, subangular to subrounded.
			50				
			55				
							injecting water at 56 feet
			60				
			65				
			70				
						SP	MEDIUM BROWN GRAVELLY SAND fine- to coarse-grained, subangular to subrounded. Fine gravel is subangular to rounded; clasts consist of volcanic breccia, andesite, granite, quartzite, diabase, quartz, chloritized andesite. Clasts are pyritic.
			75				
						GW	SANDY GRAVEL similar to above, but gravel less than 50%.
			80				

DRILL DATE
START: 7/28/94 FINISH: 7/28/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.
PROJECT No. 001-05
DATE 1/16/95

LOG OF BORING No. MMW-16
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C24a



REMARKS	Blows/0.5 Ft.	PID	SAMPLE DEPTH	SAMPLE INTERVAL	GRAPHIC LOG	USCS CLASS	DESCRIPTION
			80				
			85				
							86 to 90 feet: granite clasts are 75% of gravel
			90			Rock	LIGHT GRAY GRANITE angular chips 1/8" to 1/2", no significant fracturing.
			95				
							Boring terminated at 98.0 feet and monitor well installed.
			100				
			105				
			110				
			115				
			120				

DRILL DATE
START: 7/26/94 FINISH: 7/28/94 LOGGED By: J.Kepper DRILL RIG: Air Rotary/ Casing Drive SAMPLE TYPE: Cuttings

SOUTH PASS RESOURCES, Inc.

PROJECT No. 001-05

DATE 1/16/95

LOG OF BORING No. MMW-16
Molycorp, Inc.
Questa, New Mexico

FIGURE No. C24b

APPENDIX D

SOUTH PASS RESOURCES, Inc.
SPRI

APPENDIX D

Mine Area
1994 Water-Quality Results

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). Not correct

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).

X

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.

source of data.

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

X [illegible]

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.

* you be dewatering

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.

  Wasn't mine being dewatered in ?
- 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 (^{3}H) that disintegrates radioactively to helium (^{3}He) 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.

X

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.

See Tab D-2

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.

or active [illegible]
[illegible]

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. When

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.

SITE200

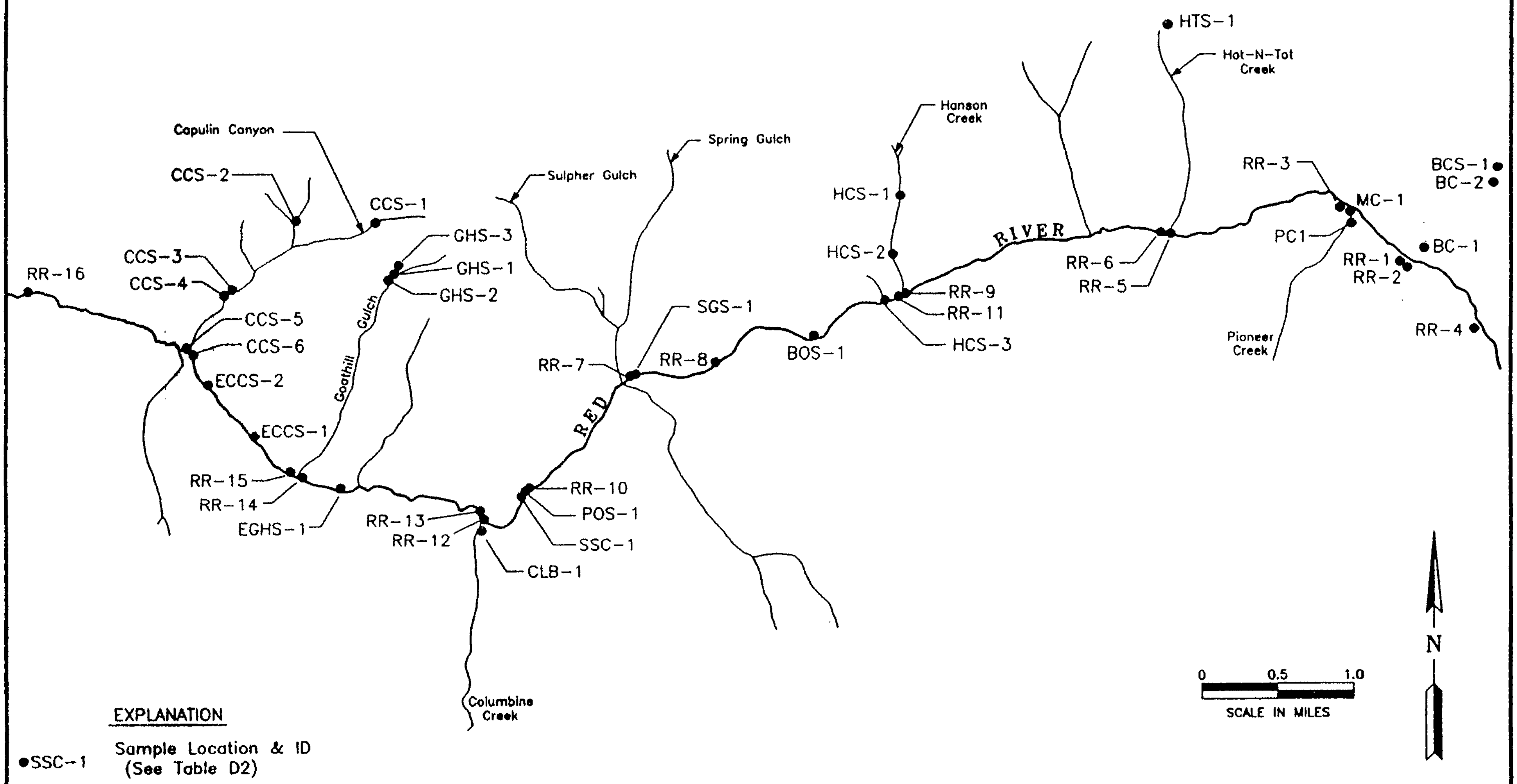
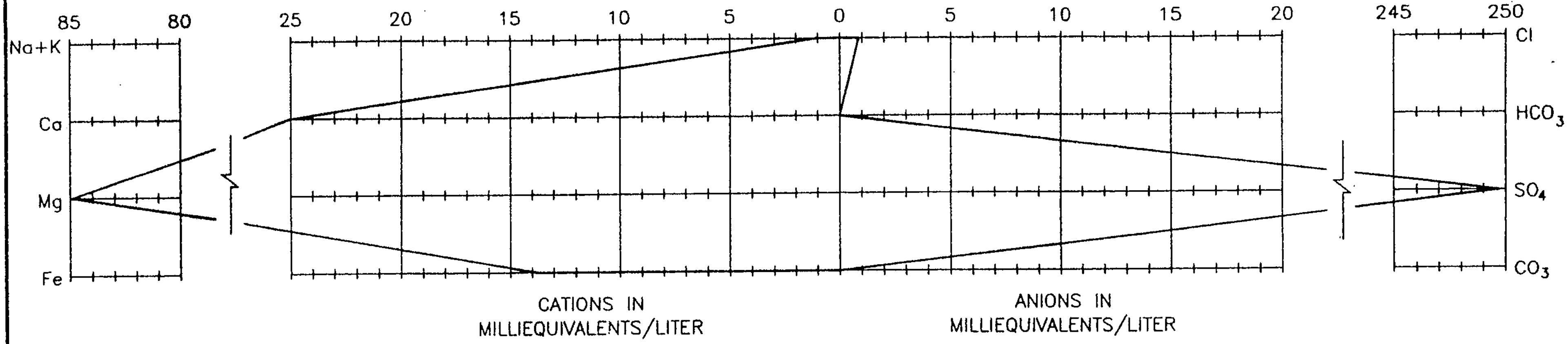


FIGURE: D1	SOUTH PASS RESOURCES, Inc.				RED RIVER & SEEP SAMPLE LOCATIONS MAY 1994 Mine Area – Molycorp, Inc. Questa, New Mexico
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

STIFF-1

pH = 3.0 CCS-1 TDS = 24,950



pH = 4.0 CCS-3 TDS = 2686

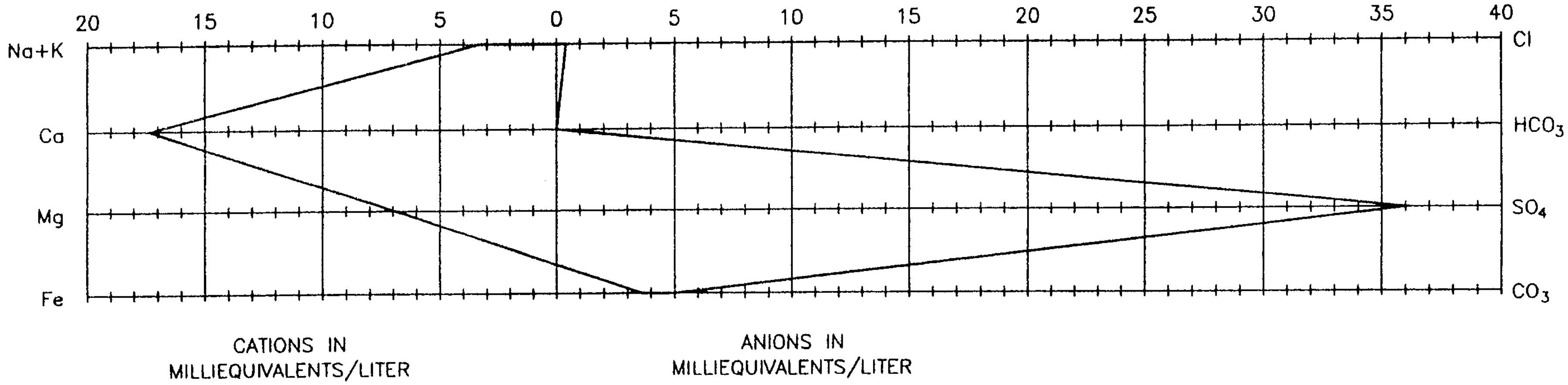


FIGURE: **D2**

SOUTH PASS RESOURCES, Inc.

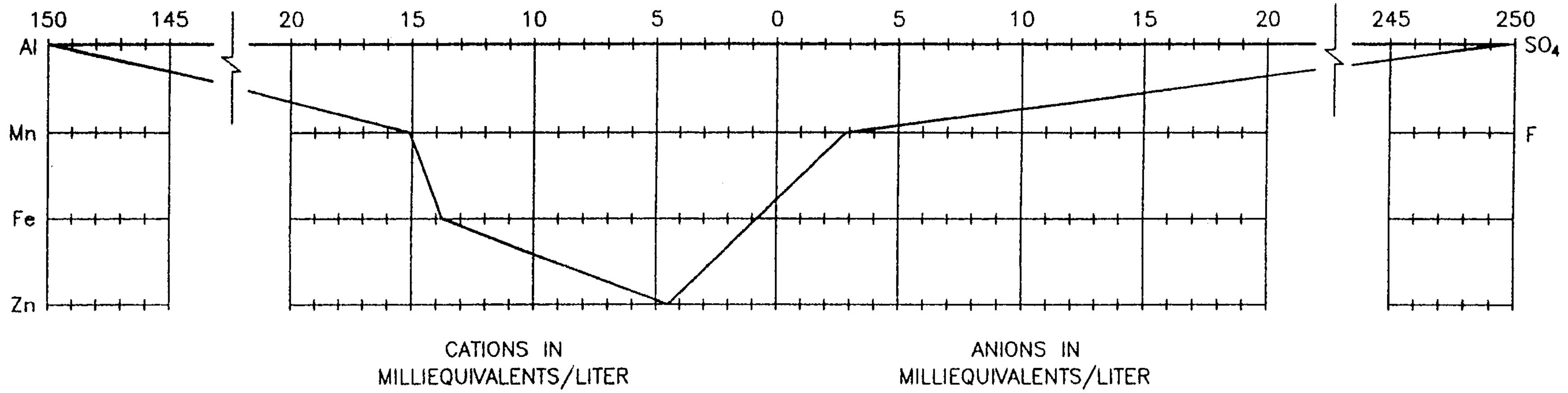
PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAMS-WASTE ROCK DUMPS AND BEDROCK SEEPS

Mine Area - Molycorp, Inc.
Questa, New Mexico

STIFF-1A

pH = 3.0 CCS-1 TDS = 24,950



pH = 4.0 CCS-3 TDS = 2686

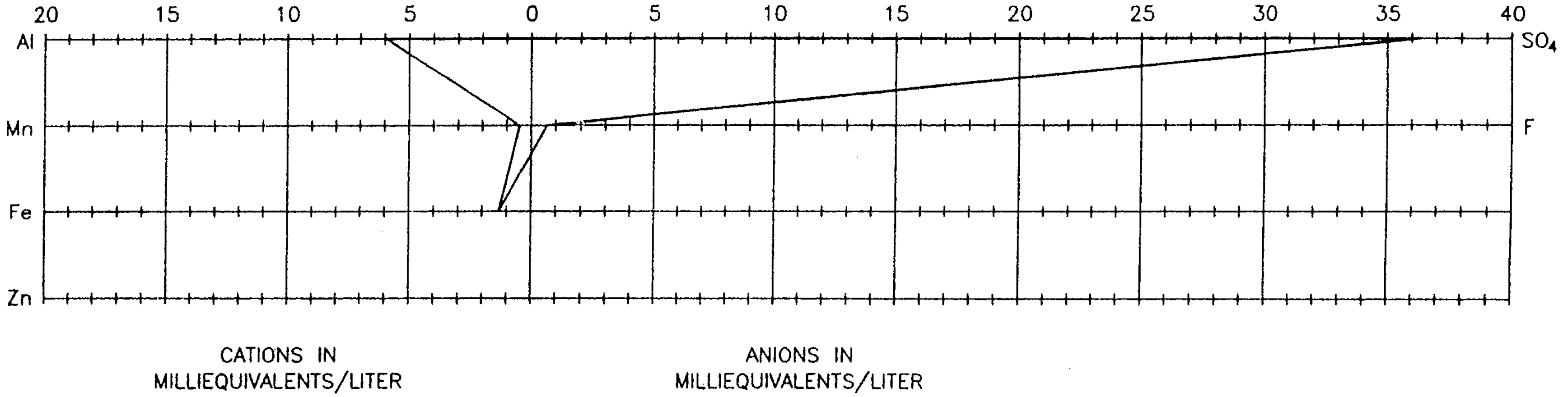
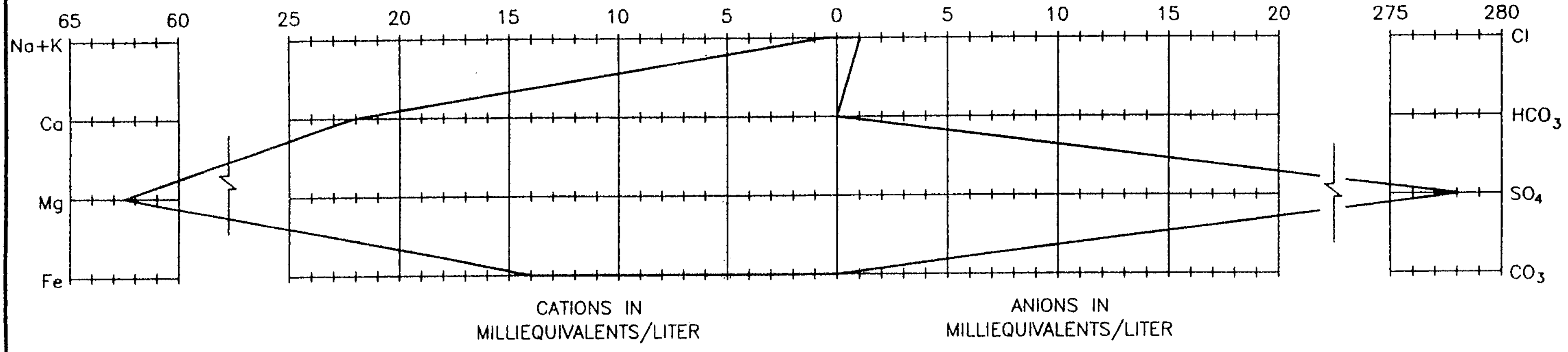


FIGURE: D 2a	SOUTH PASS RESOURCES, Inc.			STIFF DIAGRAMS-WASTE ROCK DUMPS AND BEDROCK SEEPS Mine Area – Molycorp, Inc. Questa, New Mexico
	PROJECT No.: 001–06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.

pH = 2.0 GHS-1 TDS = 23,890



pH = 2.0 GHS-3 TDS = 11,980

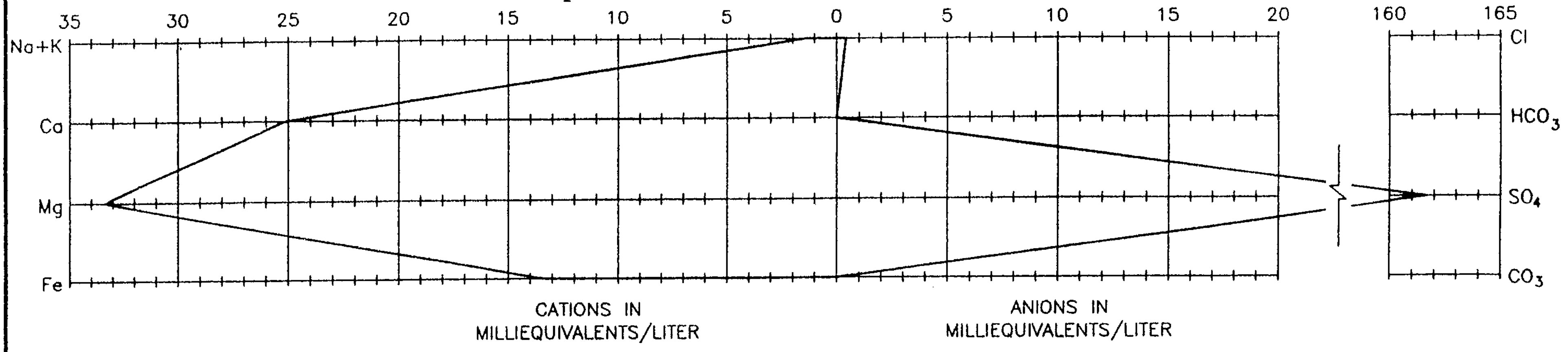


FIGURE: **D 2b**

SOUTH PASS RESOURCES, Inc.

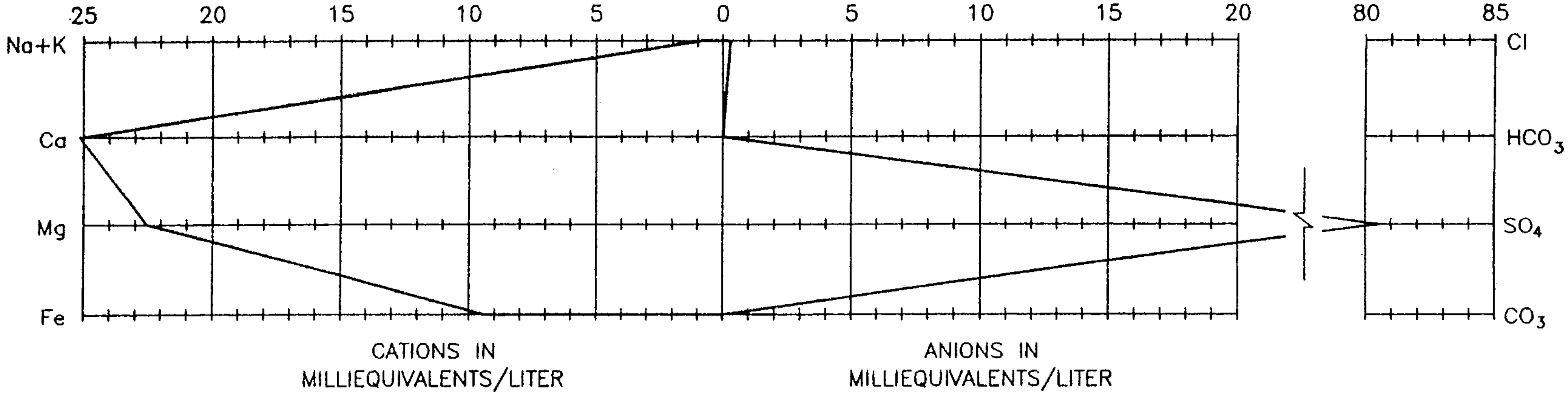
PROJECT No.: 001-06
DATE: 4/13/95
AUTHOR:
DRAWN BY: M.O'M.

STIFF DIAGRAMS-WASTE ROCK DUMPS AND BEDROCK SEEPS

Mine Area - Molycorp, Inc.
Questa, New Mexico

STIFF-4

pH = 2.5 HCS-1 TDS = 6493



pH = 2.3 HTS-1 TDS = 2610

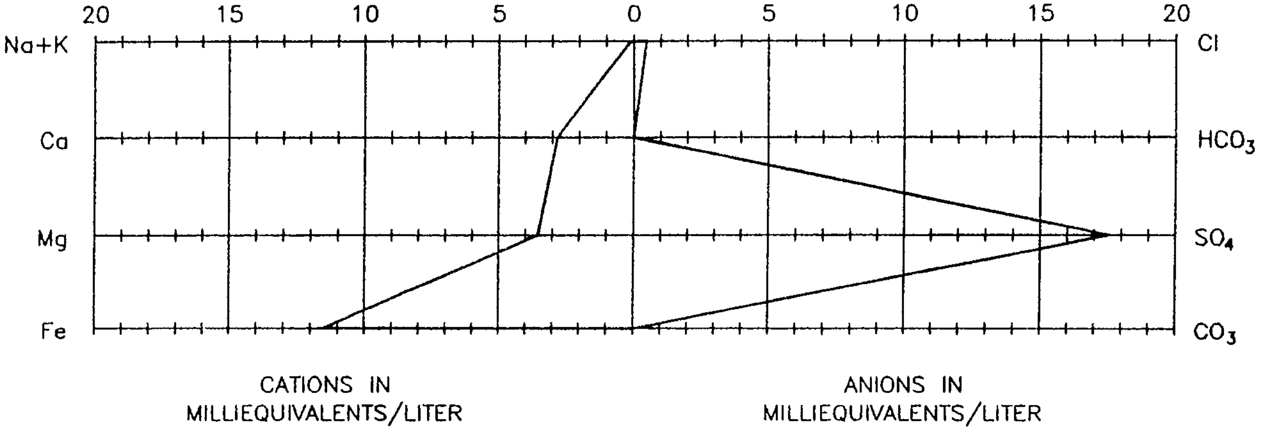
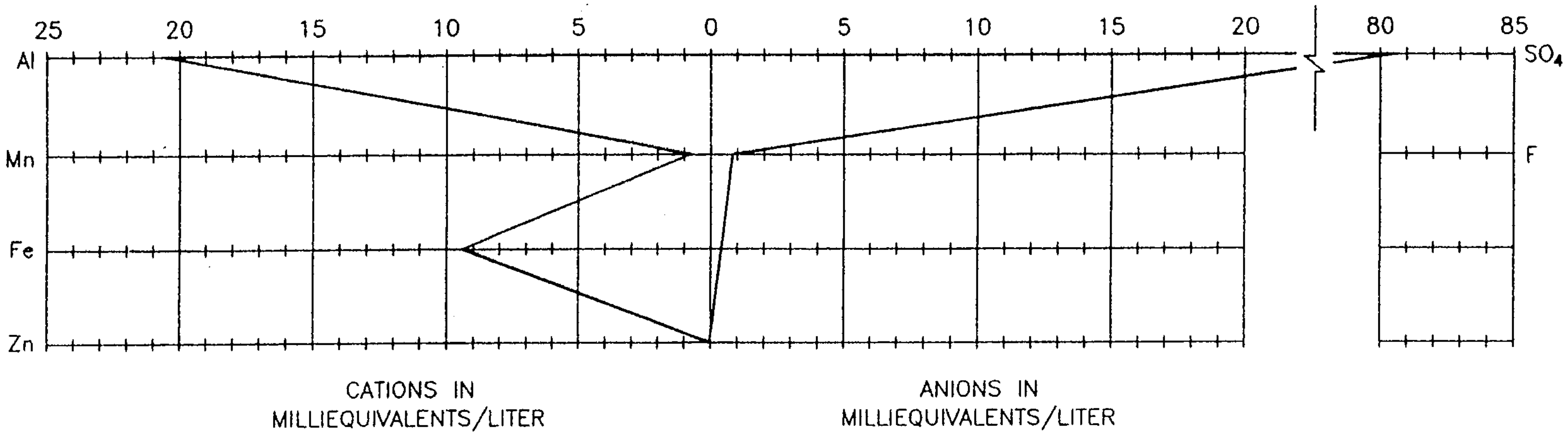


FIGURE:	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS–NATURAL SEEPS OUTSIDE MINE AREA
D3	PROJECT No.: 001–06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	Mine Area – Molycorp, Inc. Questa, New Mexico

STIFF-4A

pH = 2.5 HCS-1 TDS = 6493



pH = 2.3 HTS-1 TDS = 2610

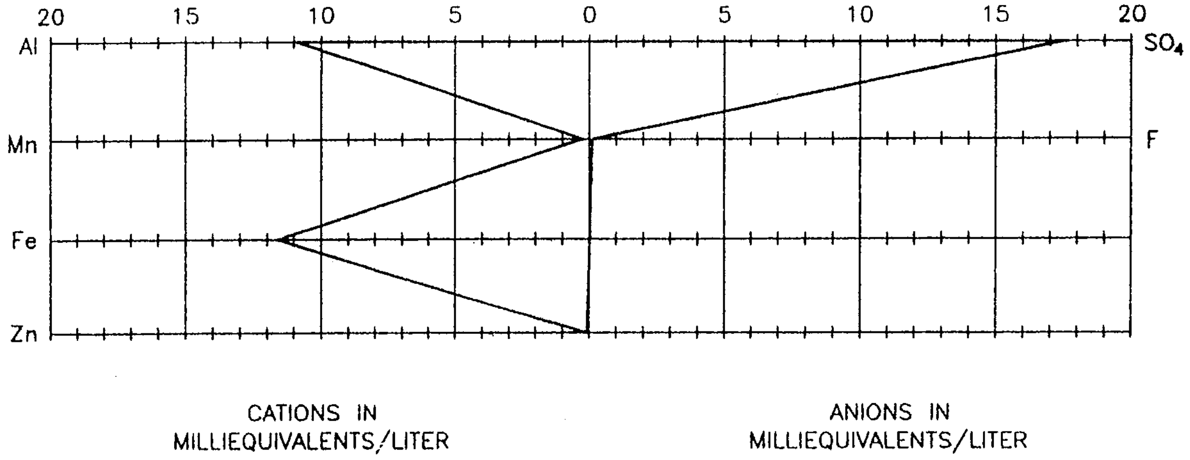


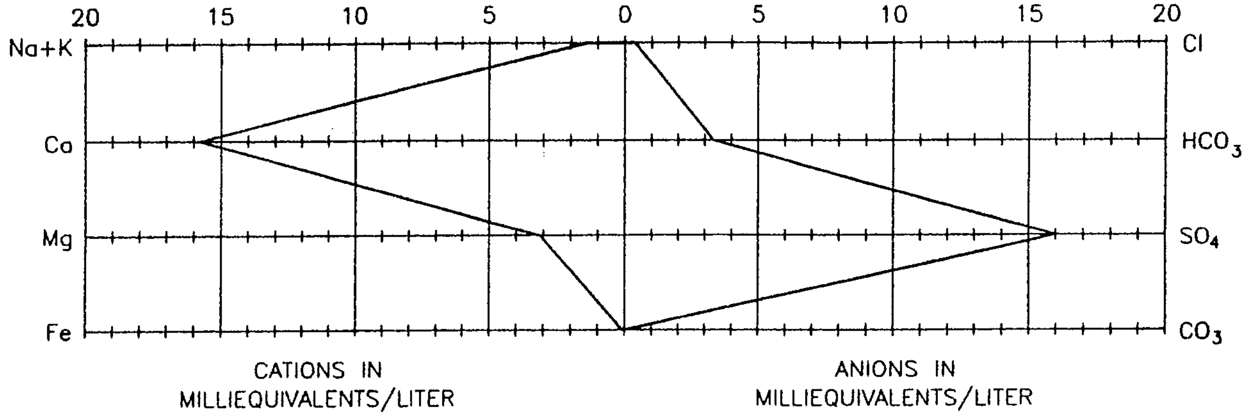
FIGURE: D 3a	SOUTH PASS RESOURCES, Inc.			
	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.

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

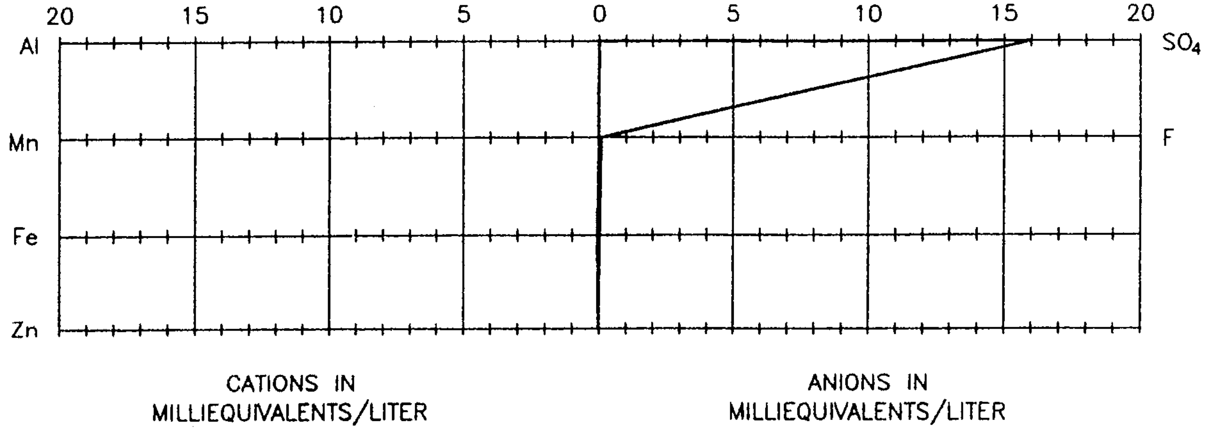


FIGURE: **D4**	SOUTH PASS RESOURCES, Inc.		
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.

STIFF DIAGRAM – MIDDLE WASTE-ROCK DUMP

Mine Area – Molycorp, Inc.
Questa, New Mexico

STIFF-8

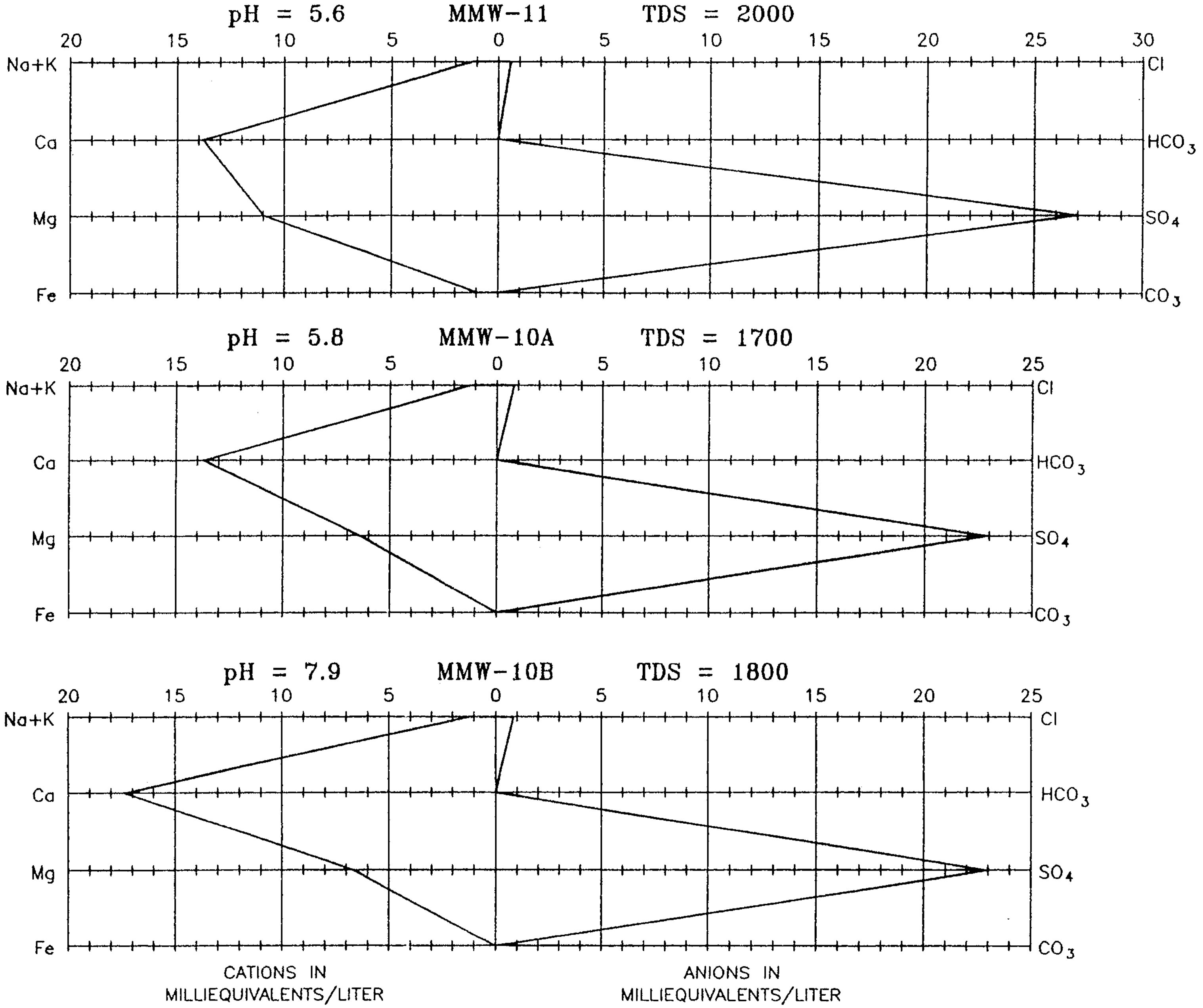


FIGURE:
D5

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

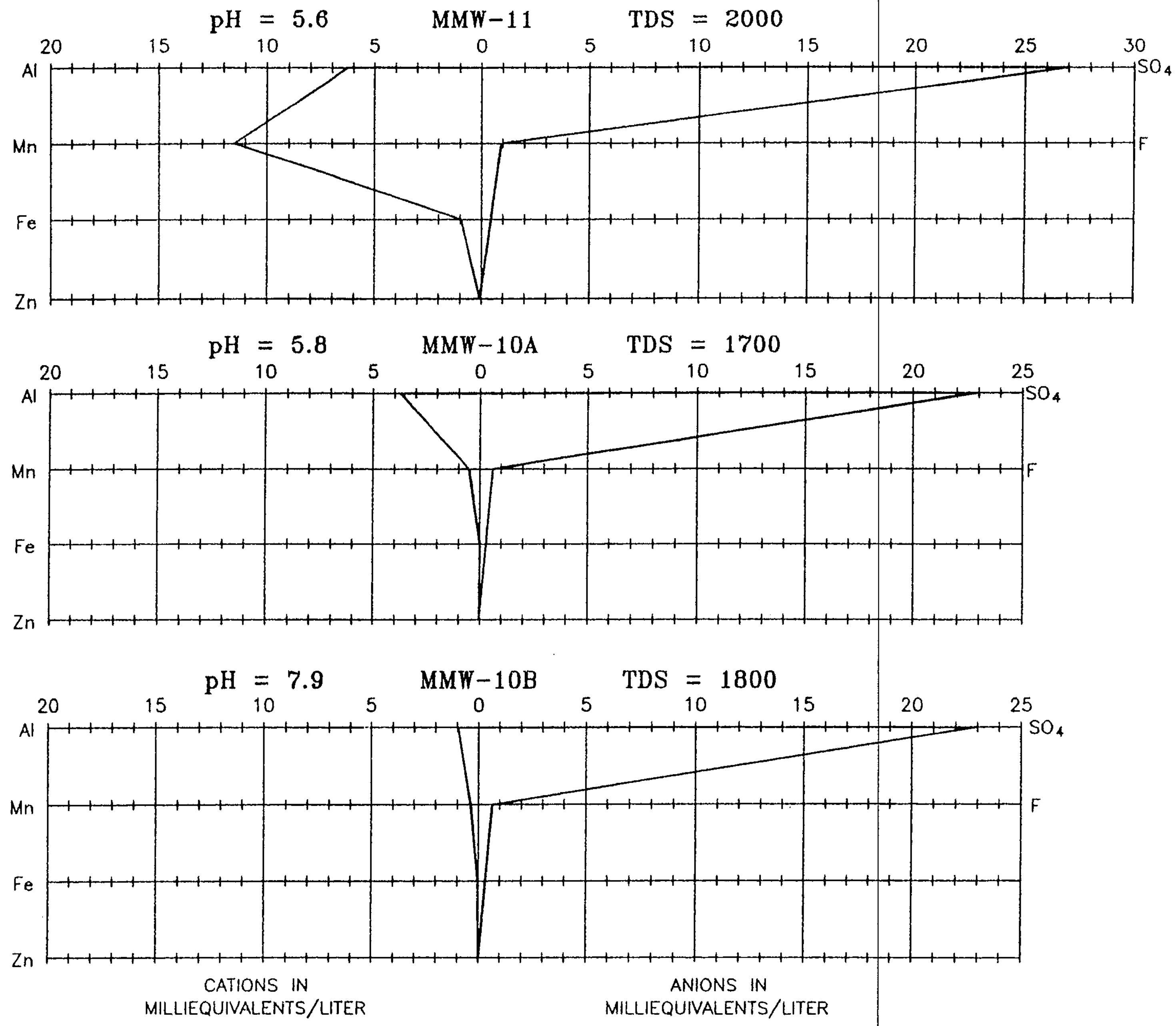
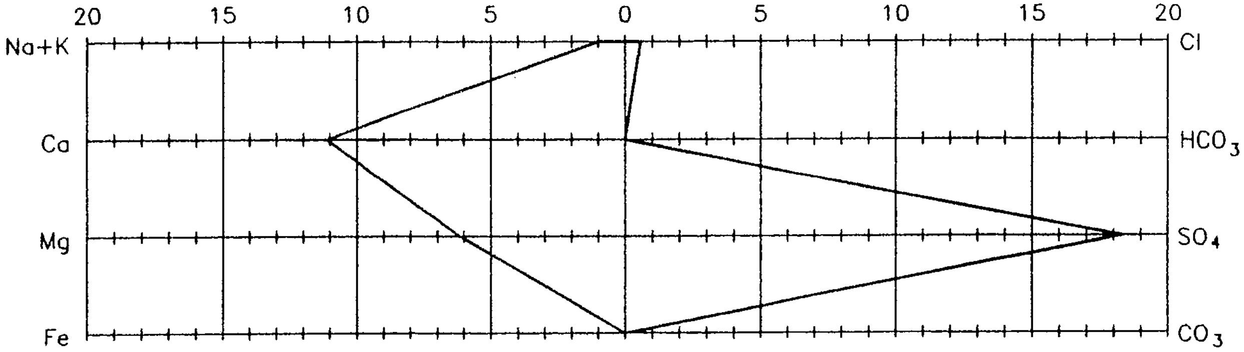


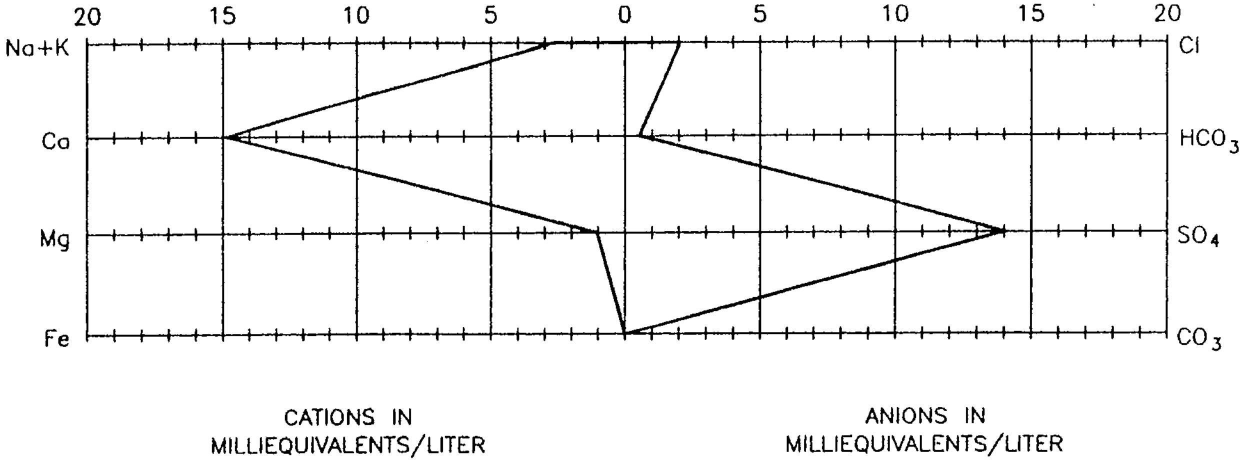
FIGURE:	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS – SUGAR SHACK SOUTH AREA
D 5a	PROJECT No.: 001–06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	Mine Area – Molycorp, Inc. Questa, New Mexico

STIFF-9

pH = 4.7 MMW-10C TDS = 1400



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

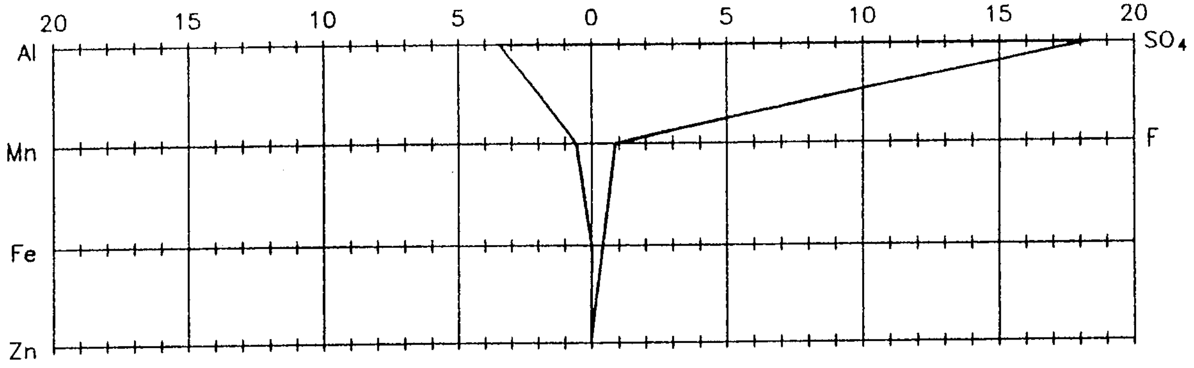


SOUTH PASS RESOURCES, Inc.			
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.

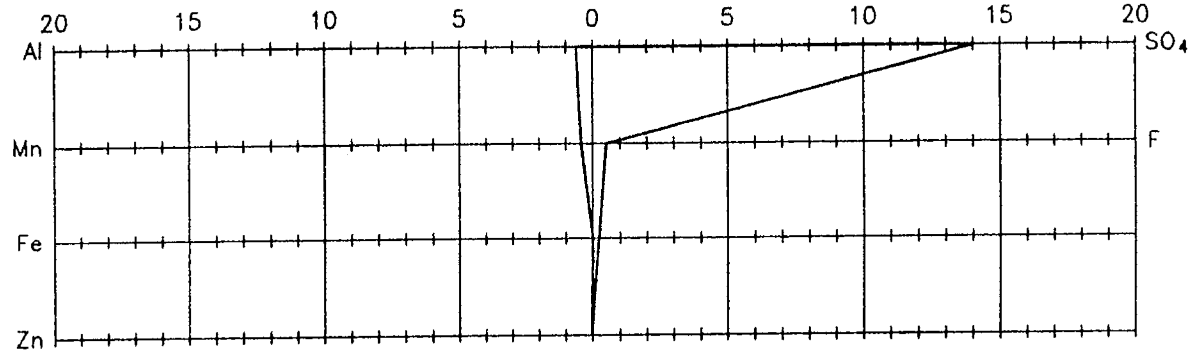
STIFF DIAGRAMS – SUGAR SHACK SOUTH AREA
Mine Area – Molycorp, Inc.
Questa, New Mexico

FIGURE:
D
5b

pH = 4.7 MMW-10C TDS = 1400



pH = 5.0 PORTAL SPRINGS TDS = 2017
(SPRI 11/94, #20)



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MILLIEQUIVALENTS/LITER

ANIONS IN
MILLIEQUIVALENTS/LITER

FIGURE:
D
5c

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-2A

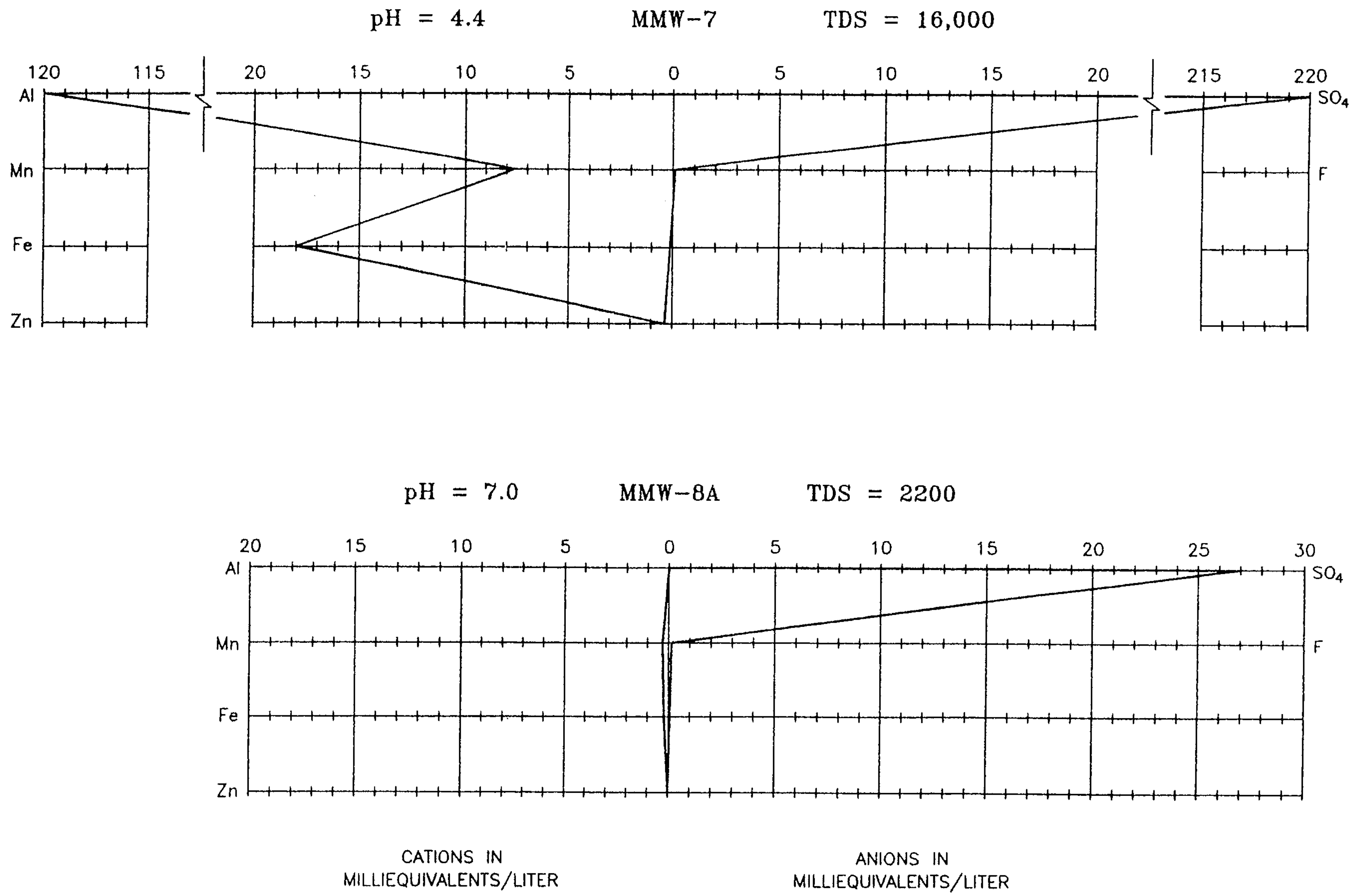
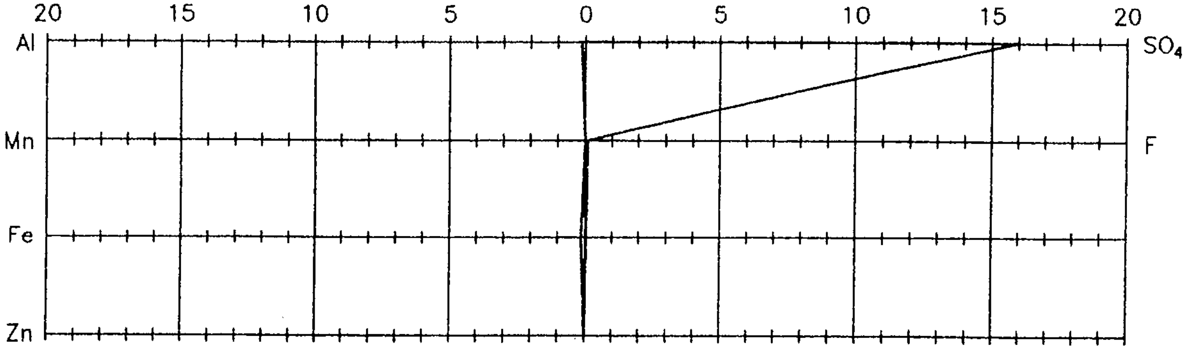
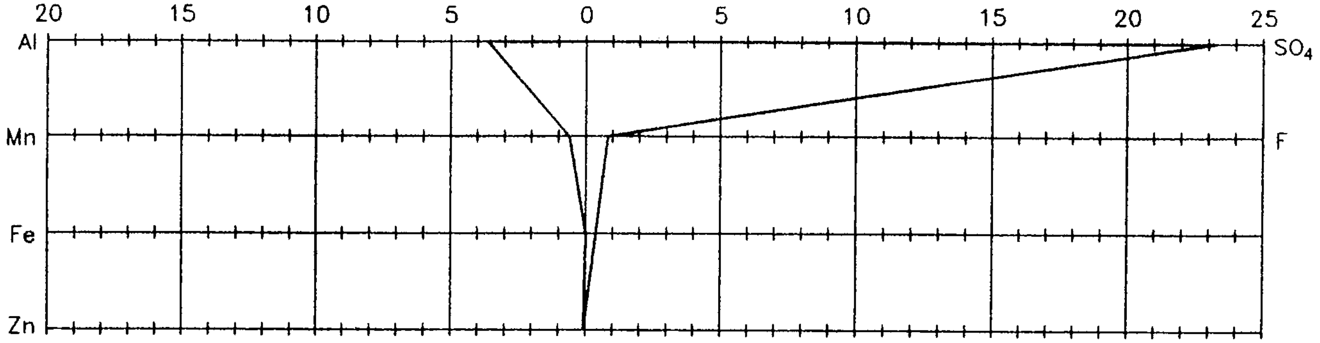


FIGURE:	SOUTH PASS RESOURCES, Inc.				STIFF DIAGRAMS - SUGAR SHACK WEST AREA Mine Area - Molycorp, Inc. Questa, New Mexico
D 6a	PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.	

pH = 6.4 MMW-8B TDS = 1100



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



CATIONS IN MILLIEQUIVALENTS/LITER

ANIONS IN MILLIEQUIVALENTS/LITER

SOUTH PASS RESOURCES, Inc.			
PROJECT No.: 001-06	DATE: 4/13/95	AUTHOR:	DRAWN BY: M.O'M.

STIFF DIAGRAMS – SUGAR SHACK WEST AREA
Mine Area – Molycorp, Inc.
Questa, New Mexico

FIGURE:
D
6c

STIFF-6

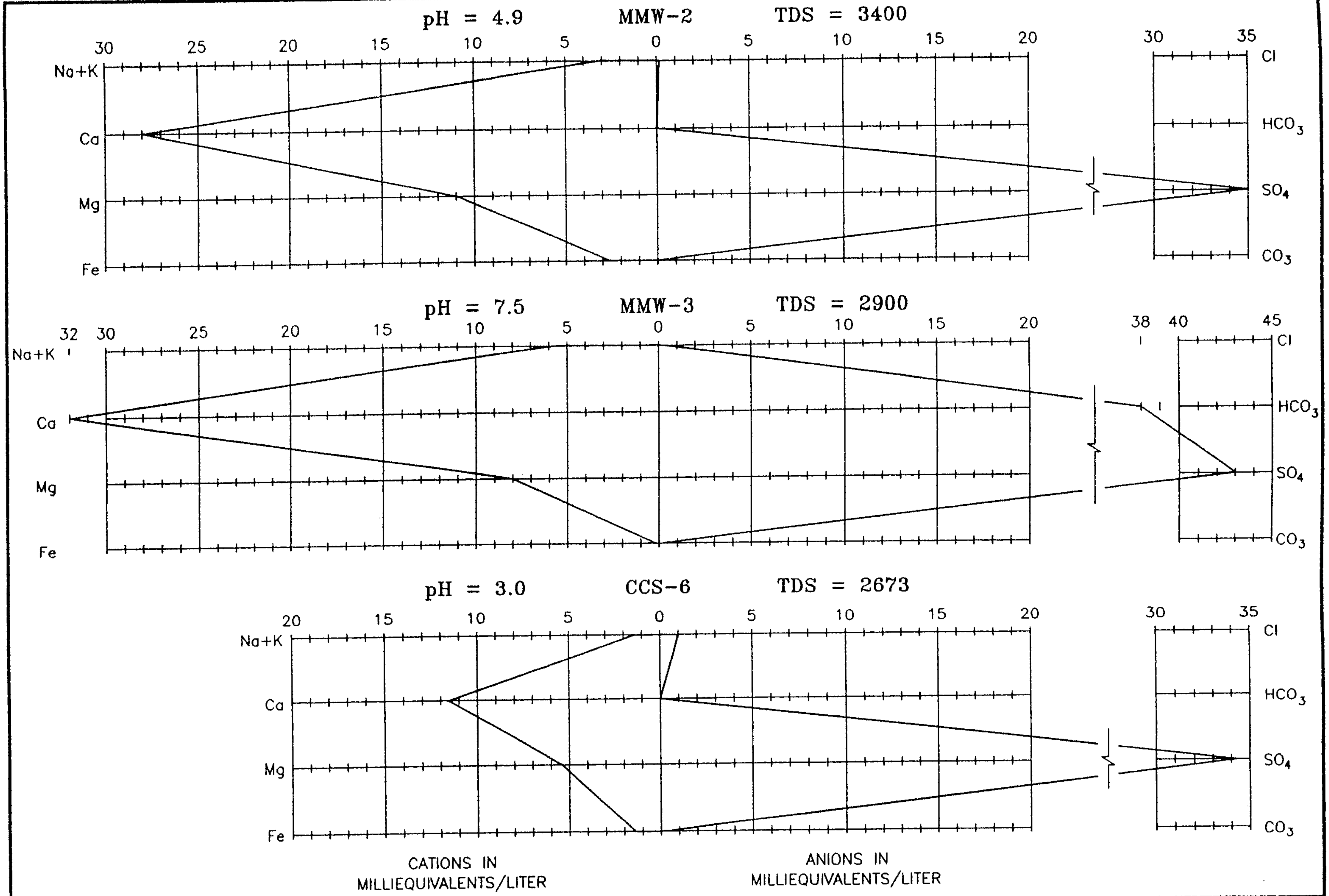


FIGURE: D7

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

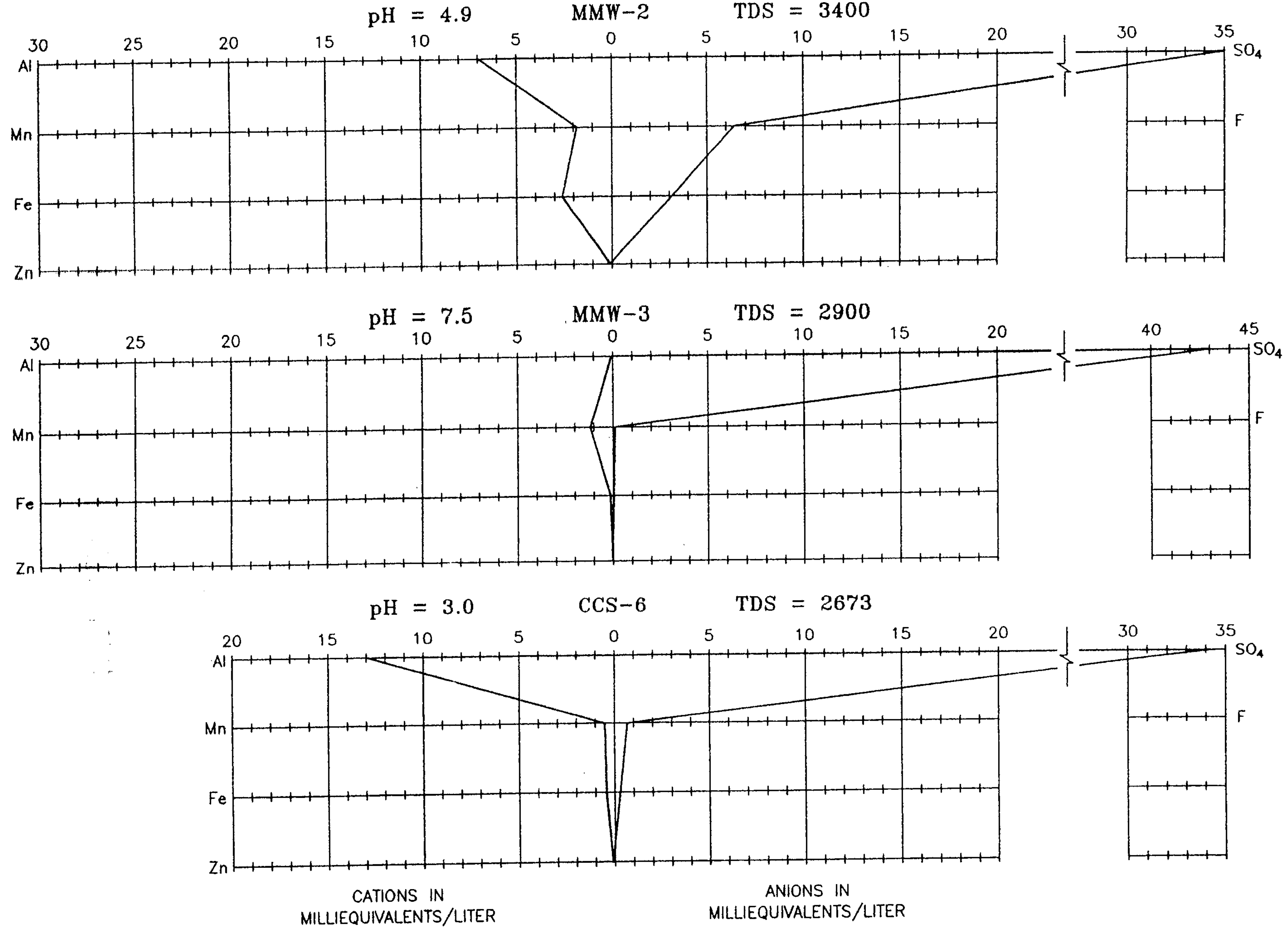


FIGURE: **D 7a**

SOUTH PASS RESOURCES, Inc.

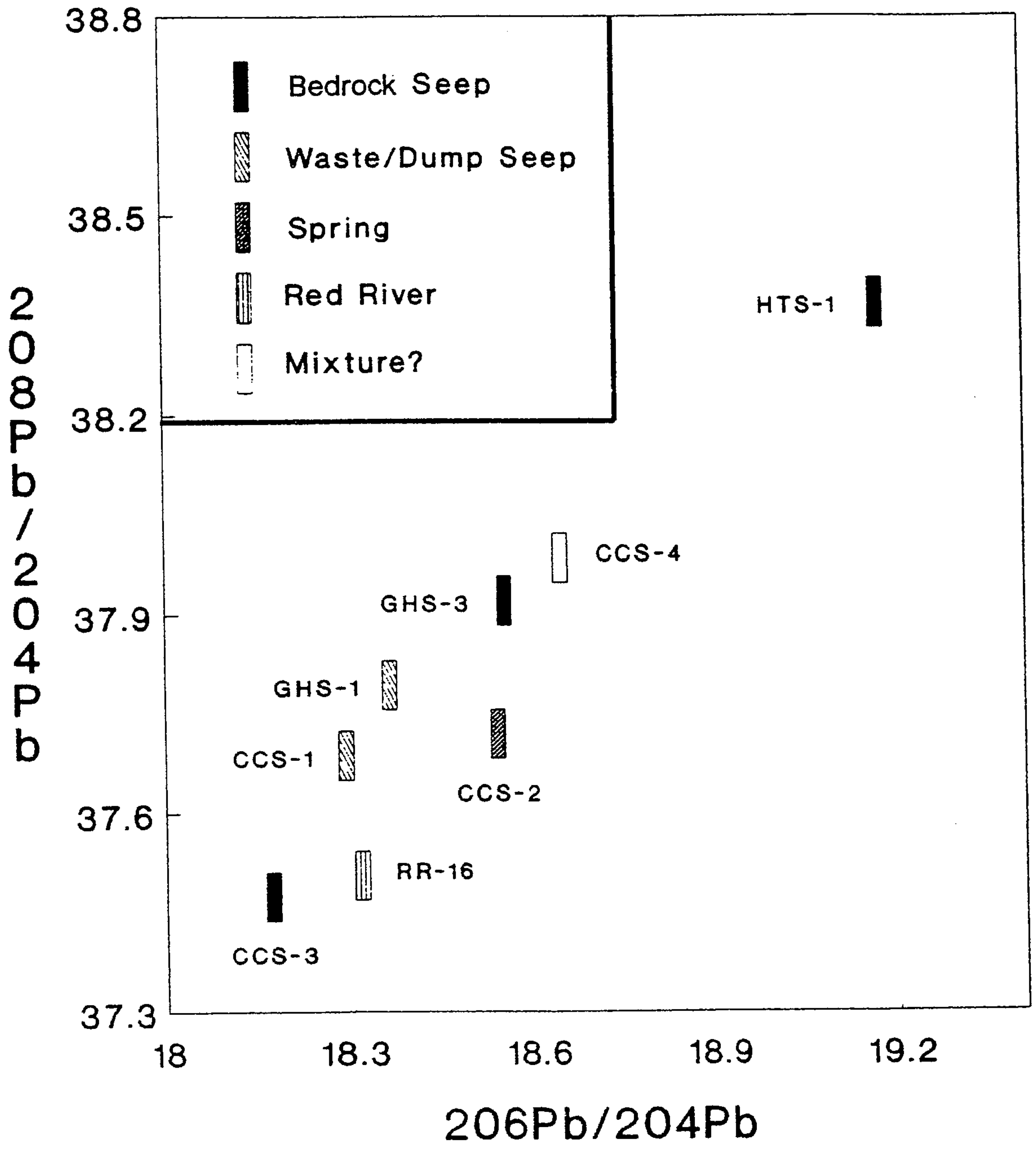
PROJECT No.:	DATE:	AUTHOR:	DRAWN BY:
001-06	4/13/95		M.O'M.

STIFF DIAGRAM - CAPULIN CANYON AREA

Mine Area - Molycorp, Inc.
Questa, New Mexico

ISOTOPES

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.

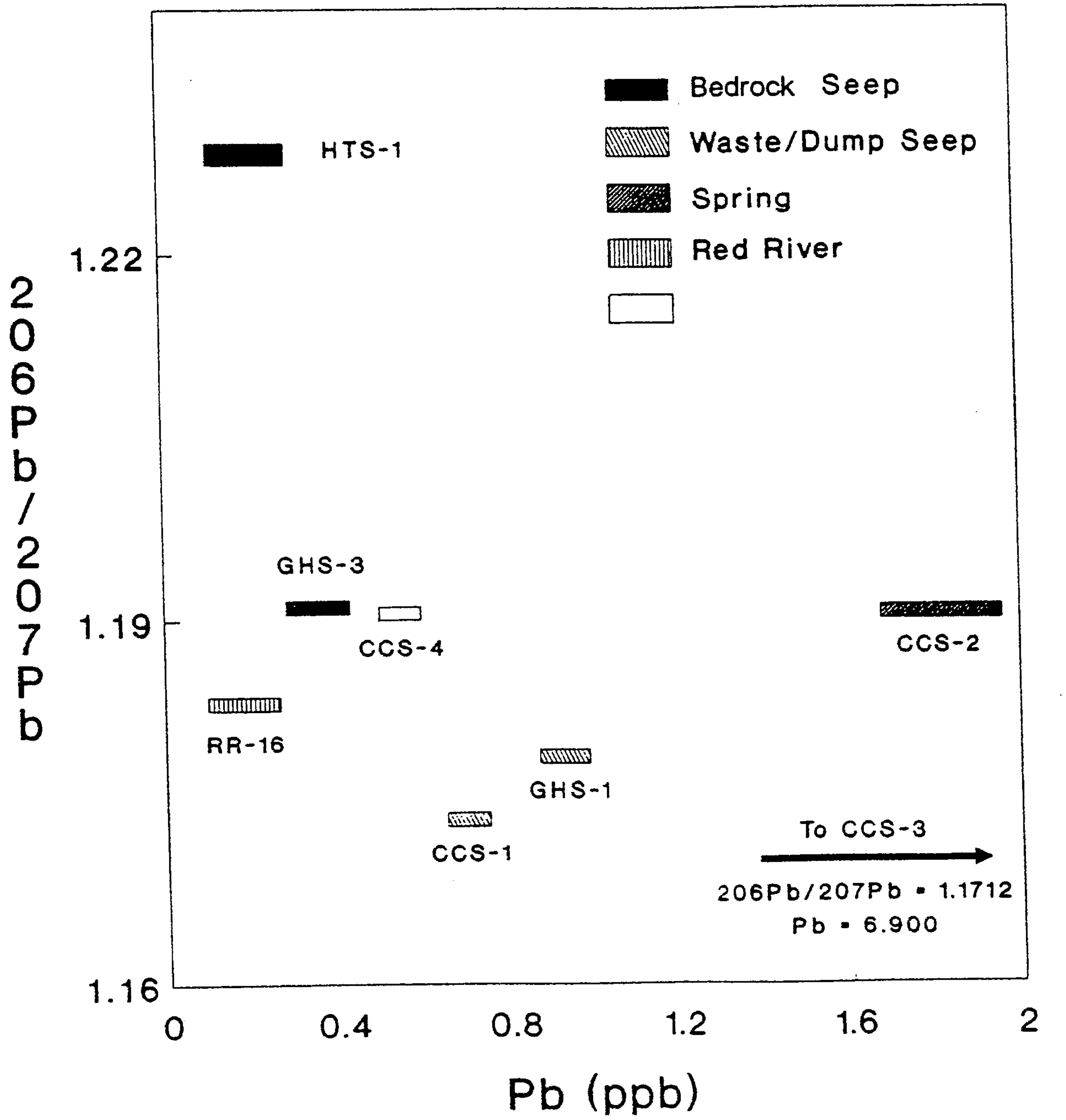
SOUTH PASS RESOURCES, Inc.

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

208Pb/204Pb vs 206Pb/204Pb
Tailings Area - Molycorp, Inc.
Questa, New Mexico

FIGURE: 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.

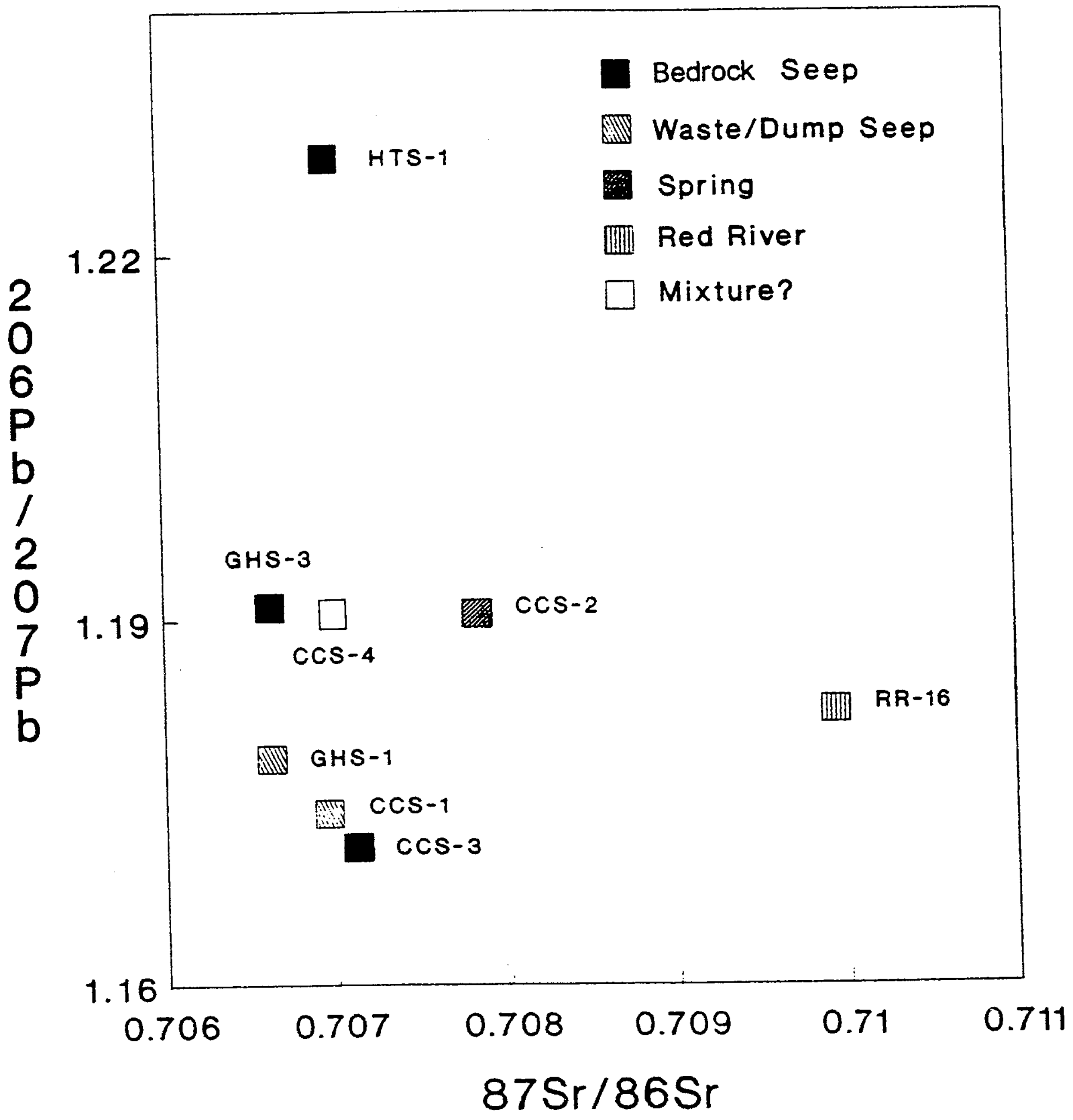
SOUTH PASS RESOURCES, Inc.
PROJECT No.: 001-06
DATE: 4/13/95
AUTHOR:
DRAWN BY: M.O'M.

206Pb/207Pb vs Pb Concentration
Tailings Area – Molycorp, Inc.
Questa, New Mexico

FIGURE: D10

ISOTOPES

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.

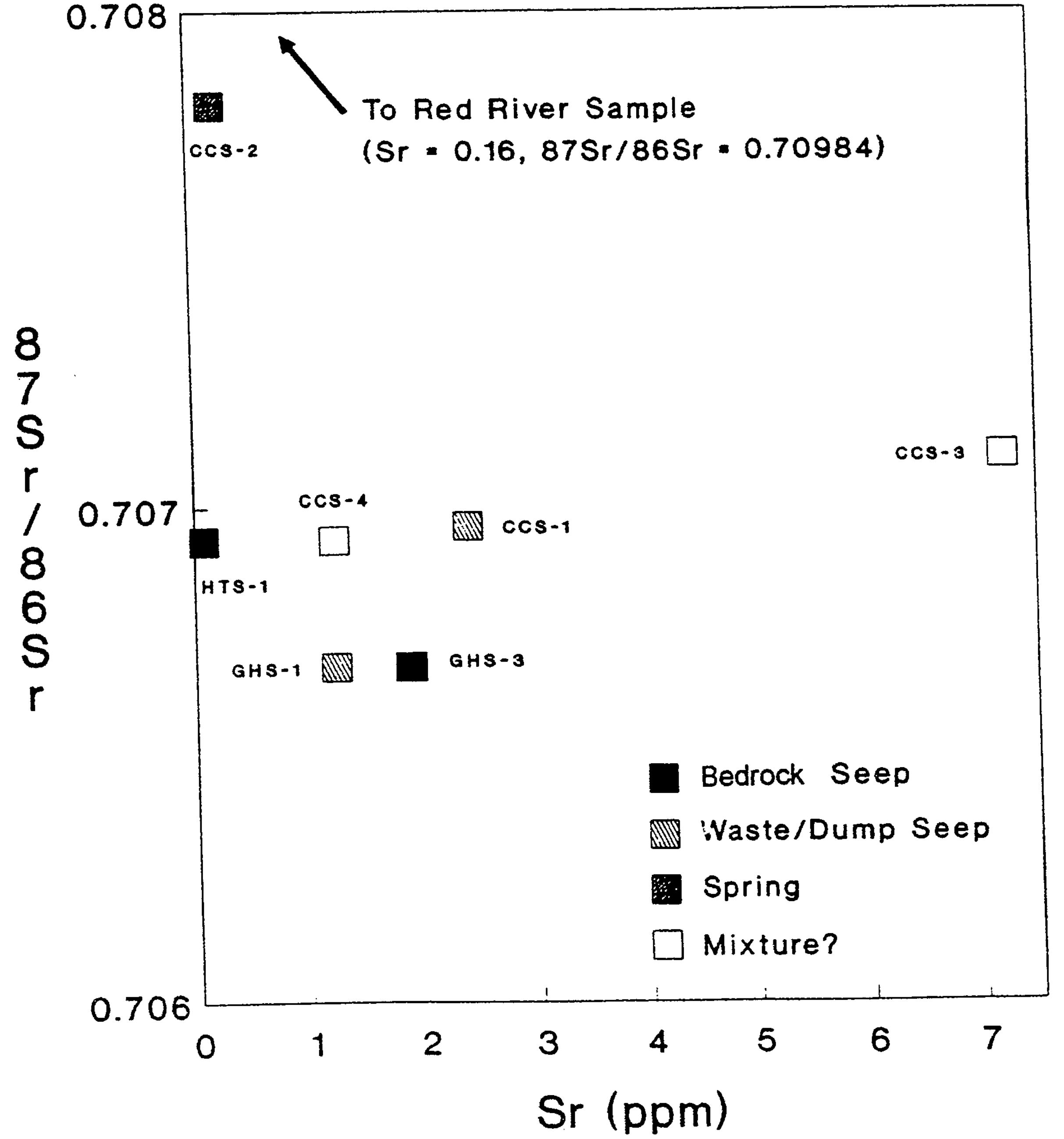
PROJECT No.: 001-06
DATE: 4/13/95
AUTHOR:
DRAWN BY: M.O'M.

206pB/207Pb vs 87Sr/86Sr
Tailings Area – Molycorp, Inc.
Questa, New Mexico

FIGURE: D11

ISOTOPES

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.: 001-06
DATE: 4/13/95
AUTHOR:
DRAWN BY: 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 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°)	Conduc-tivity (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/BitCrk	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°)	Conduc-tivity (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*	Conduc-tivity (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.

[illegible]

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

APPENDIX E

Data from Mine Area Aquifer Drawdown and Recovery Tests

MMW-10A PUMP TEST

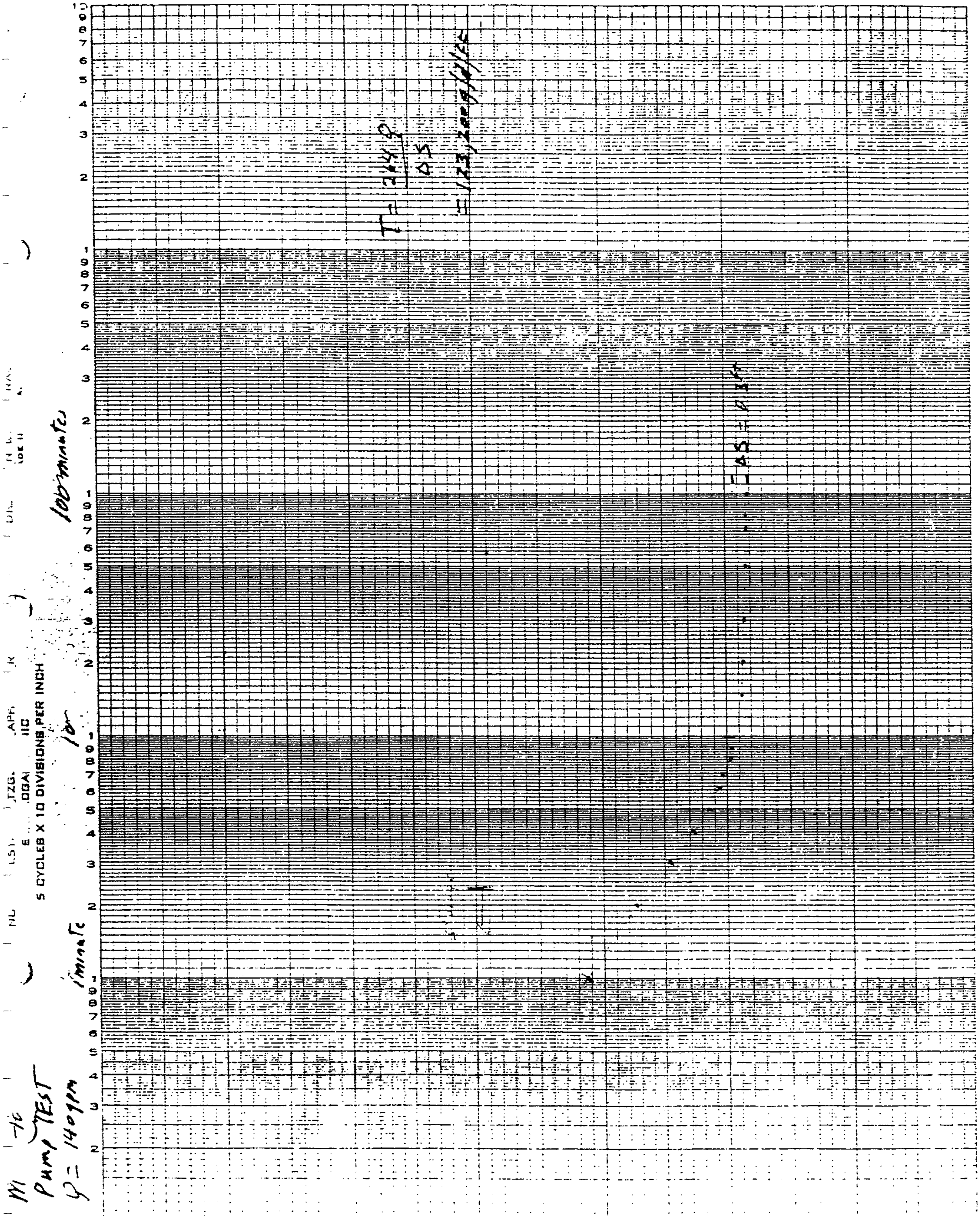


FIGURE E1

MMW-10A RECOVERY TEST

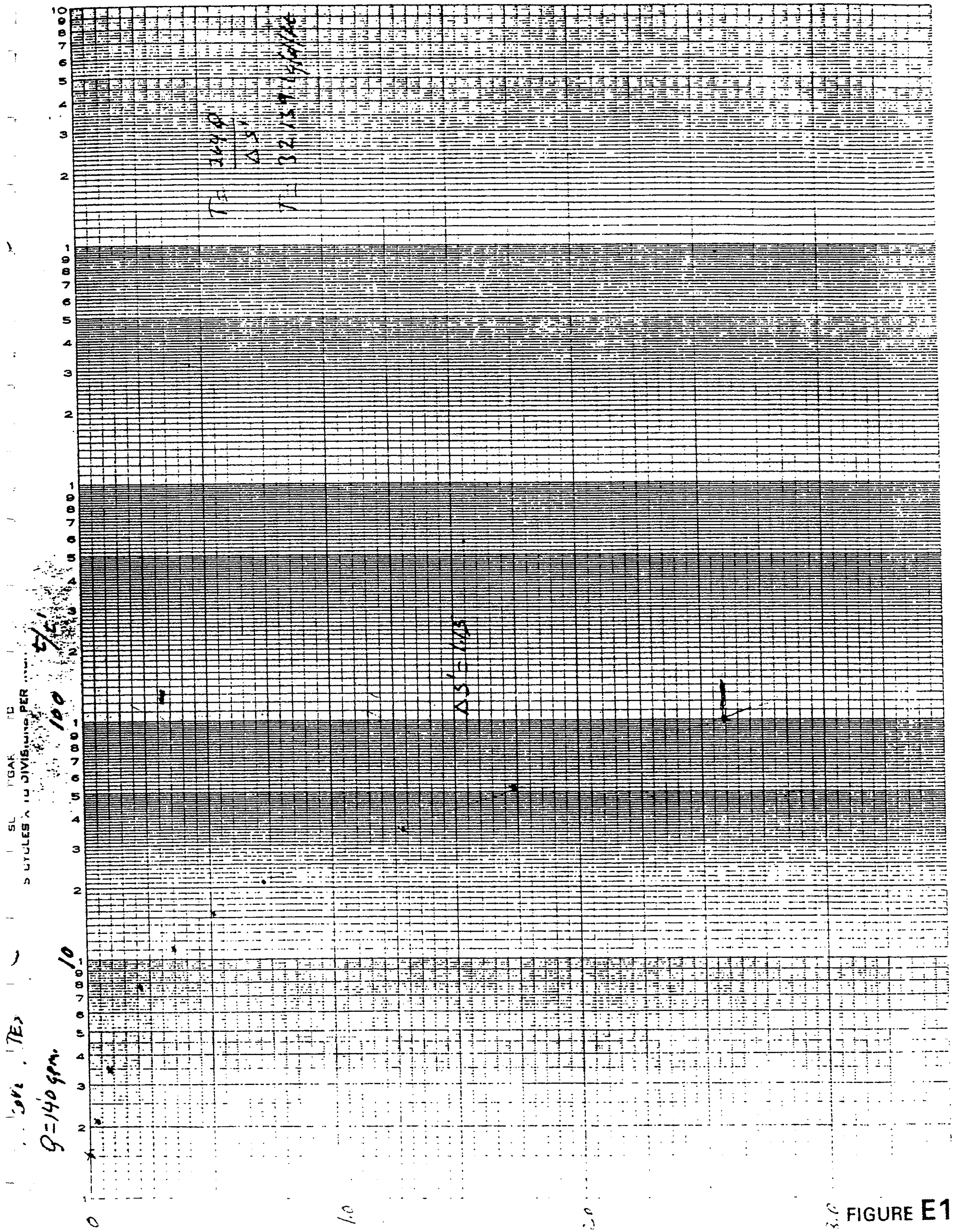


FIGURE E1a

DEWATERING CURVE FOR ROCK BETWEEN A LEVEL OF 7686' (POINT ON DEWATERING) LEVEL AND TOP OF UNDERGROUND MINE, SEPT. 19, 1994

Q = 450gpm

ΔS = 49 ft

$T = \frac{264Q}{\Delta S}$

2424 g/day/ft

$\frac{2424}{476}$ =5.09 g/day/ft

$\begin{array}{r} 7686 \\ -7210 \\ \hline 476 \end{array}$ Top Undercut

Thick Rock Below 7686'
To Top of Mine 476
9/19/94 – 11/14/94

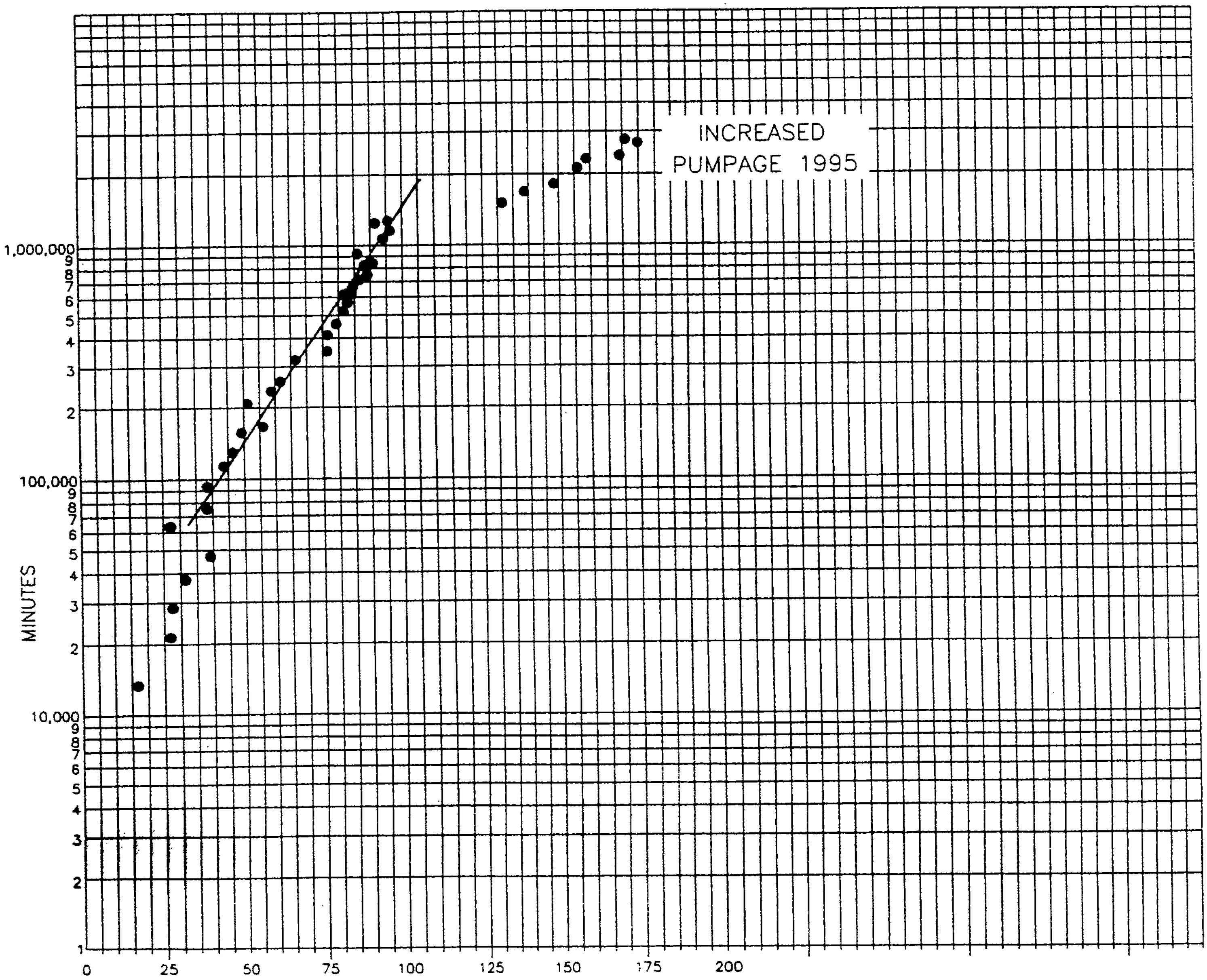


FIGURE E2