EPA 530-R-94-013
NTIS PB94-170-305

TECHNICAL RESOURCE DOCUMENT

EXTRACTION AND BENEFICIATION OF ORES AND MINERALS

VOLUME 2

GOLD

August 1994

U.S. Environmental Protection Agency
Office of Solid Waste
Special Waste Branch
401 M Street, SW
Washington, DC 20460

DISCLAIMER AND ACKNOWLEDGEMENTS

This document was prepared by the U.S. Environmental Protection Agency (EPA). The mention of company or product names is not to be considered an endorsement by the U.S. Government or the EPA.

This Technical Resource Document consists of five sections. The first section is EPA's Profile of the gold industry; the remaining four sections are Site Visit Reports from site visits conducted by EPA. The Profile Section was distributed for review to the U.S. Department of the Interior's Bureau of Mines and Bureau of Land Management, the U.S. Department of Agriculture's Forest Service, the Western Governors Association, the Interstate Mining Compact Commission, the American Mining Congress, and Environmental Public Interest Groups. Summaries of the comments and EPA's responses are presented as an appendix to the Profile Section. The Site Visit Report Sections were reviewed by individual company, state, and Federal representatives who participated in the site visit. Comments and EPA responses are included as Appendices to the specific Site Visit Sections. EPA is grateful to all individuals who took the time to review sections of this Technical Resource Document.

The use of the terms "extraction," "beneficiation," and "mineral processing" in the Profile section of this document is not intended to classify any waste streams for the purposes of regulatory interpretation or application. Rather, these terms are used in the context of common industry terminology.

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1.0 MINING INDUSTRY PROFILE: GOLD

1.1 INTRODUCTION

This Industry Profile presents the results of U.S. Environmental Protection Agency (EPA) research into the domestic gold mining industry and is one of a series of profiles of major mining sectors. Additional profiles describe lead/zinc mining, copper mining, iron mining, and several industrial mineral sectors, as presented in the current literature. EPA has prepared these profiles to enhance and update its understanding of the mining industry and to support mining program development by the states. EPA believes the profiles represent current environmental management practice as described in the literature.

Each profile addresses extraction and beneficiation of ores. The scope of the Resource Conservation and Recovery Act (RCRA) as it applies to mining waste was amended in 1980 when Congress passed the Bevill Amendment, Section 3001(b)(3)(A). The Bevill Amendment states that "solid waste from the extraction, beneficiation, and processing of ores and minerals" is excluded from the definition of hazardous waste under Subtitle C of RCRA (40 CFR 261.4(b)(7)). The exemption was conditional upon EPA's completion of studies required by RCRA Section 8002(f) and (p) on the environmental and health consequences of the disposal and use of these wastes. EPA segregated extraction and beneficiation wastes from processing wastes. EPA submitted the initial results of these studies in the 1985 *Report to Congress: Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden From Uranium Mining, and Oil Shale* (U.S. EPA 1985). In July 1986, EPA made a regulatory determination that regulation of extraction and beneficiation wastes under Subtitle C was not appropriate (51 FR 24496; July 3, 1986). EPA concluded that Subtitle C controls were unnecessary and found that a wide variety of existing Federal and State programs already addressed many of the risks posed by extraction and beneficiation wastes. Instead of regulating extraction and beneficiation wastes as hazardous wastes under Subtitle C, EPA indicated that these wastes should be controlled under Subtitle D of RCRA.

EPA reported their initial findings on wastes from mineral processing from the studies required by the Bevill Amendment in the 1990 *Report to Congress: Special Wastes From Mineral Processing* (U.S. EPA 1990). This report covered 20 specific mineral processing wastes; none involved gold processing wastes. In June 1991, EPA issued a regulatory determination (56 FR 27300) stating that regulation of these 20 mineral processing wastes as hazardous wastes under RCRA Subtitle C is inappropriate or infeasible. Eighteen of the wastes are subject to applicable state requirements. The remaining two wastes (phosphogypsum and phosphoric acid process waste water) are currently being evaluated under the authority of the Toxic Substances Control Act (TSCA) to investigate pollution prevention alternatives. Any mineral processing wastes not specifically included in this list of 20 wastes no longer qualifies for the exclusion (54 FR 36592). Due to the timing of this decision and the limited numbers of industry wastes at issue, gold processing wastes are not addressed in this profile.

In addition to preparing profiles, EPA has undertaken a variety of activities to support state mine waste programs. These activities include visits to a number of mine sites; compilation of data from State regulatory agencies on waste characteristics, releases, and environmental effects; preparing summaries of mining-related sites on the Superfund National Priorities List (NPL); and an examination of specific waste management practices and technologies. Site visit reports are presented as later sections of this Technical Resource Document. EPA has also conducted studies of State mining-related regulatory programs and their implementation.

The purpose of this Profile is to provide additional information on the domestic gold mining industry. The report describes gold extraction and beneficiation operations with specific reference to the wastes associated with these operations. The Profile is based on literature reviews and on comments received on earlier drafts. This Profile complements, but was developed independently of, other EPA activities, including those described above.

This Profile briefly characterizes the geology of gold ores and the economics of the industry. Following this discussion is a review of gold extraction and beneficiation methods; this section provides the context for descriptions of wastes and materials managed by the industry, as well as a discussion of the potential environmental effects that may result from gold mining. The Profile concludes with a description of the current regulatory programs that apply to the gold mining industry as implemented by EPA, Federal land management agencies, and selected States.

1.2 ECONOMIC CHARACTERIZATION OF THE INDUSTRY

In 1990, U.S. gold operations produced 9.5 million troy ounces of gold from ore, valued at $3.6 billion. This represented an increase of 10 percent over the amount of gold produced domestically in 1989. Production levels in 1991 were 9.3 million ounces of gold; production for 1992 was estimated to be 10.3 million troy ounces (U.S. DOI, Bureau of Mines 1992). Prior to 1990, a significant portion of market demand was satisfied by importing refined products (U.S. DOI, Bureau of Mines 1990a). By contrast, the Gold Institute is projecting an $8 billion surplus in domestic production between 1990 and 1994.

Historically, gold has been the principal medium of international monetary exchange, but its role has changed significantly in recent years. Between 1934 and 1972, the United States monetary system worked on a gold standard at a fixed rate of $35 per ounce. After leaving the gold standard in 1975 and allowing private ownership of the metal, the U.S. gold market grew rapidly and the price of gold skyrocketed to a high of $850 per ounce in January 1980. Since that time, the price of gold has dropped (U.S. DOI, Geological Survey 1973; U.S. DOI, Bureau of Mines 1985). Gold had an average selling price of $438.31 per ounce in 1988 and is currently being traded at $360 to $400 per ounce.

New gold mines continue to open (24 in 1989), and existing mines are expanding their production capabilities. The United States is now the second largest gold producer in the world. In the 1993 *Mineral Commodity Summaries,* the Bureau estimates that the number of lode mines increased to 200 and that approximately 200 small placer operations were in operation, most in Alaska. The numbers do not account for the thousands of "recreational" gold mines; these recreational mines are typically operated by two to three individuals who may only work on weekends or on a seasonal basis.

Historically, gold has been mined in virtually every State but has been concentrated in the following 15: Alaska, Arizona, California, Colorado, Idaho, Michigan, Montana, Nevada, New Mexico, North Carolina, Oregon, South Carolina, South Dakota, Utah, and Washington. State production figures available for 1991 include Nevada (61 percent of newly mined domestic gold or 5.7 million troy ounces), California (10 percent), Montana (6 percent), South Dakota (6 percent), Colorado (1 percent), Arizona (1 percent), Alaska (1 percent), and Idaho (1 percent). The 25 leading domestic gold-producing mines (1991), in order of output, are listed in Table 1-1

Table 1-1. Twenty-Five Leading Gold-Producing Mines in the United States, 1991, in Order of Output

Rank	Mine	County and State	Operator	Source of Gold
1[a]	Nevada Mines Operations	Elko and Eureka, NV	Newmont Gold Co.	Gold Ore
2	Goldstrike	Eureka, NV	Barrick Mercur Gold Mines, Inc.	Gold Ore
2	Bingham Canyon	Salt Lake, UT	Kennecott-Utah Copper Corp.	Copper Ore
4	Jerritt Canyon (Enfield Bell)	Elko, NV	Freeport-McMoran Gold Co.	Gold Ore
5	Smoky Valley Common Operation	Nye, NV	Round Mountain Gold Corp.	Gold Ore
6	Homestake	Lawrence, SD	Homestake Mining Co.	Gold Ore
7	McCoy and Cove	Lander, NV	Echo Bay Mining Co.	Gold Ore
8	McLaughlin	Napa, CA	Homestake Mining Co.	Gold Ore
9	Chimney Creek	Humboldt, NV	Gold Fields Mining Co.	Gold Ore
10	Fortitude and Surprise	Lander, NV	Battle Mountain Gold Co.	Gold Ore
11	Bulldog	Hye, NV	Bond Gold, Bullfrog, Inc.	Gold Ore
12	Mesquite	Imperial, CA	Goldfields Mining Co.	Gold Ore
13	Getchell	Humboldt, NV	FMG, Inc.	Gold Ore
14	Sleeper	Humboldt, NV	Amax Gold, Inc.	Gold Ore
15	Cannon	Chelan, WA	Asamera Minerals (U.S.), Inc.	Gold Ore
16	Ridgeway	Fairfield, SC	Ridgeway Mining Co.	Gold Ore
17	Jamestown	Tuolumne, CA	Sonora Mining Corp.	Gold Ore
18	Paradise Peak	Nye, NV	FMC Gold Co.	Gold Ore
19	Rabbit Creek	Humboldt, NV	Rabbit Creek Mining, Inc.	Gold Ore
20	Barney's Canyon	Salt Lake City, UT	Kennecott Corp.	Gold Ore
21	Continental	Silver Bow, MT	Montana Resources	Copper Ore
22	Zortman-Landusky	Phillips, MT	Pegasus Gold, Inc.	Gold Ore
23	Golden Sunlight	Jefferson, MT	Golden Sunlight Mines, Inc.	Gold Ore
24	Wind Mountain	Washoe, NV	Amax Gold, Inc.	Gold Ore
25	Foley Ridge & Amie Creek	Lawrence, SD	Wharf Resources	Gold Ore

[a]Modified at the request of Newmont Gold Co. to read Nevada Mines Operations instead of Carlin Mines Complex.

(Source: U.S. DOI, Bureau of Mines 1992.)

. In 1991, these mines accounted for 68 percent of all domestically produced gold. According to the Bureau of Mines, approximately 10 percent of gold production is generated as a by-product of other mining (U.S. DOI, Bureau of Mines 1992, 1993).

According to the Bureau of Mines, gold industry employment has experienced a slight downturn since 1990. Employment at mines and mills was 16,000 in 1990 and was estimated to be 14,400 in 1992. No data were available on employment at processing facilities (U.S. DOI, Bureau of Mines 1993).

Another trend in the gold industry has been joint exploration and/or production ventures between two or more firms. An example of this trend is the recent agreement between Canyon Resources Corporation and Kennecott Exploration Company to jointly mine a large California gold reserve.

A general description of the typical domestic uses for gold products is shown in Table 1-2. From this table, it can be seen that common end uses include jewelry and the arts, dental, and industrial products. Although the majority of refined gold is used in jewelry manufacturing, gold is becoming increasingly important in other

Table 1-2. U.S. Consumption of Gold [a], by End Use Sector [b]

End Use	1991 (kilograms)
Jewelry and the Arts:	
Karat Gold	78,875
Fine Gold for Electroplating	373
Gold-Filled and Other	3,819
Total	84,067
Dental	8,485
Industrial	
Karat Gold	1,068
Fine Gold for Electroplating	12,624
Gold-Filled and Other	8,110
Total[c]	21,802
Small Items for Investment[d]	--
Grand Total[c]	114,354

[a]Gold consumed in fabricated products only; does not include monetary bullion.
[b]Data may include estimates.
[c]Data may not add to totals shown because of independent rounding.
[d]Fabricated bars, medallions, coins, etc.

(Source: U.S. DOI, Bureau of Mines 1992.)

industries. Gold has superior electric and thermal conductive abilities, reflects infrared radiation and most of the visible spectrum, alloys easily with other metals, and resists corrosion and tarnishing. These characteristics make gold valuable in high-technology products such as computers, communications equipment, and spacecraft. In addition, gold has high malleability and ductility, making it extremely easy to work with. In the electronics industry, gold is used in printed circuit boards, connectors, keyboard contractors, miniaturized circuitry, and in some semiconductors (U.S. DOI, Bureau of Mines 1992).

1.3 ORE CHARACTERIZATION

Gold occurs in a variety of geologic environments. Estimates of average abundance in the Earth's crust are on the order of 0.003 to 0.004 parts per million (ppm) (U.S. DOI, Geological Survey 1973). Deposits considered to be economically recoverable at current market prices may contain as little as 0.69 to 1.37 ppm [0.02 to 0.04 troy ounces of gold per ton of rock (oz/t)], depending on the mining method, total reserves, and the geologic setting of the deposit.

Geologic processes act to concentrate gold into minable ore deposits. All gold deposits, except placer deposits, are formed by hydrothermal processes. Hydrothermal systems form in numerous geologic environments, ranging from dynamic systems associated with magmatic intrusives to low-energy systems associated with deep fluid circulation heated by geothermal heat flow. Deposits formed from hydrothermal systems flowing at or near the surface (1,000 to 2,500 feet deep) are called epithermal deposits, while those formed deeper are called mesothermal deposits. Combinations of the various types of hydrothermal systems in various host rocks create variations in deposit morphology, grade ranges (variation in gold content), and wall rock alteration. Deposit morphology ranges in a continuum from veins several feet thick and hundreds to thousands of feet in vertical and lateral dimensions (formed by mineral precipitation in voids in the host rock) to disseminated mineralization (essentially micro veinlets) pervading through the host rock in irregular pods up to several hundred feet in dimension.

Placer deposits are formed when gold-bearing lode ores are exposed to chemical and physical weathering and subsequent erosion, resulting in transportation and deposition to form sedimentary deposits. The less-resistant minerals, such as pyrite, are quickly oxidized and leached from the host rock while gold and other resistant minerals (i.e., silica) persist. Generally, placers are found as sedimentary deposits associated with stream gravels or beach sand, although some aeolian (windblown sand) deposits exist. When transported in a stream, gold's high specific gravity causes it to be deposited in areas where the stream's velocity decreases, settling behind rocks and natural riffles. The particle size and composition of placer gold deposits usually depend on the distance from the source and the composition of the original lode deposit. Nugget size decreases downstream because of the hydraulic gradient. Native gold (60 percent - 90 percent gold) is generally alloyed with silver and, infrequently, with copper and other metals. These metals are more soluble than gold, and as they are removed, the gold is concentrated, and the percentage of gold in the nugget or particle is increased. For this reason, placer deposits farthest from the source tend to be more pure (Park and MacDiarmid 1975). Over time, placer gold deposits can be buried and lithified to form fossil placers. Placer gold deposits are discussed in more detail in a separate Technical Resource Document.

Grades range in all deposit types from subeconomic margins to high-grade cores. High grade varies with mining methods but usually refers to ores greater than 0.1 or 0.2 oz/t. Likewise, average deposit grades are economic distinctions. Deposits requiring high-cost mining and milling methods may require bulk averages of 0.25 oz/t or more, at 0.15 or higher cutoffs. Those deposits that are amenable to the lowest-cost mining and milling methods may average 0.03 to 0.04 oz/t with an ore-to-waste separation grade of 0.01 oz/t. Alteration of host rocks surrounding the gold mineralization affects mining and recovery methods and waste rock characteristics. Various types of alteration are silicification (replacement of host rock minerals with quartz), decalcification (acid leaching of carbonate minerals), argillization (replacement by clay minerals), carbonatization (addition of carbonate minerals), and calcsilicate skarnification (replacement of carbonate minerals by calcium-silicate minerals).

Gold deposits may be categorized based on similarities in geologic environment and genetic hydrothermal factors. Recent data show that the 25 largest gold producing mines may be grouped into four types: sediment-hosted disseminated gold (SHDG), volcanic-hosted epithermal deposits, porphyry copper-related deposits, and greenstone gold-quartz vein deposits (U.S. DOI, Bureau of Mines 1990c).

1.3.1 Types of Gold Ore Deposits

1.3.1.1 Sediment-Hosted Disseminated Gold

These deposits are hosted by silty-sandy carbonate sediments. Epithermal hydrothermal systems alter and deposit gold in the sediments. Alteration decalcifies, argillizes, or silicifies the sediments. Gold mineralization is associated with the introduction of sulfide minerals and petroleum-based organic carbon. Sulfide contents typically range from trace to 5 percent. Gold is typically disseminated throughout the altered sediments. The largest mines of this type are the Goldstrike Mine and the Gold Quarry Mine of the Carlin Trend.

1.3.1.2 Volcanic-Hosted Epithermal Deposits

These deposits are found in intrusive/volcanic complexes and are formed by epithermal hydrothermal systems directly associated with cooling intrusive or volcanic rocks. Wall rock alteration may be minor to strong silicification and argillization. Sulfide contents range from 1 to 15 percent. There is a broad range of deposit morphologies from distinct, large veins to stockwork disseminations. Likewise, there are distinct and broad chemical/mineralogic variations. Typical subgroups are Au-Te vein deposits (Telluride, Colorado), base metal/carbonate vein deposits (Creede, Colorado), Au-Ag/ quartz-adularia vein deposits (Tonopay, Nevada), Au quartz-alunite vein deposits (Goldfield, Nevada), and Au-Ag Hot Springs deposits (McLaughlin, California).

1.3.1.3 Porphyry Copper-Related Deposits

Porphyry copper deposits are formed from hydrothermal systems developed and zoned around discrete intrusive granite stocks at depths of 2 to 2.5 km. The stocks may intrude both sediment or volcanic rocks and form deposits. Wall rock alteration is zoned around the stock and variable, depending on host rocks. Sulfide minerals, primarily pyrite, copper-sulfides, and molybdenum sulfides, are zoned in proportions of 1 to 15 percent around the stock. Many porphyry copper deposits contain low grades of (less than 0.01 oz/t) gold but produce significant gold as a byproduct of the large tonnages mined for the copper (Bingham Canyon, Utah).

Associated with porphyry hydrothermal systems hosted by sedimentary rocks are skarn deposits. Skarns are formed where the porphyry hydrothermal system interacts with limestone sediments, the result being complete calc-silicate skarn alteration of the limestone. Iron and base metal sulfide content often approaches 50 percent. Some skarns are sufficiently gold-enriched to be mined as primary gold deposits (Fortitude, Nevada).

1.3.1.4 Greenstone Gold Quartz Vein Deposits

Very generally grouped, these deposits are distinct veins in Greenschist facies metamorphosed deep sea sediments. The veins are mesothermal deposits generally formed during metamorphism. Carbonate alteration invades the wall rocks around the veins. Sulfide contents are typically nil in the veins and wall rocks. Only two deposits in the United States fall into this category, but their gold production is significant. The Homestake Mine, South Dakota, is a deposit hosted in an Archean iron formation. Gold is associated with quartz veinlets distributed through distinct horizons in the iron formation. The Mother lode vein system in California is distinct gold-quartz veins in Mesozoic argillites (Jamestown, California). Erosion of these veins produced the rich placer deposits of California.

1.3.2 Mineral Content

The mineral content or assemblage of a deposit is the result of reactions between hydrothermal solutions and the wall rock, influenced by wall rock chemistry, solution chemistry, temperature, and pressure. Most gold ores contain some amount of sulfur-bearing minerals; carbonate deposits may also contain carbonaceous material. The weathering environment affecting the ore body following deposition is determined mainly by the location of the water table in relation to the deposit. Ores above the water table, in the vadose or unsaturated zone, will tend to be oxidized (referred to as "oxide ores"), while ores below the water table will usually be unoxidized (referred to as "sulfide ores").

Gold ores may contain varying amounts of arsenic, antimony, mercury, thallium, sulfur, base metal sulfides, other precious metals, and sulfosalts. The amount of these constituents depends on the nature of the deposit and the amount of weathering that has occurred. Subsequent alteration of the ore by oxidation influences both gold recovery and the byproducts of extracting the ore. Sulfide minerals oxidize to form either oxides or sulfosalt minerals. Leaching of sulfides or other minerals

Table 1-3. Spectrographic Analyses of Samples of Various Types of Unoxidized Ores, Oxidized and Leached-Oxidized Ores, Carlin Gold Deposit, Lynn Window, Eureka Co., NV

Element	Normal[a]	Normal[a]	Siliceous[a]	Pyritic[a]	Carbon-aceous[a]	Arsenical[a]	Oxidized[a]	Leached-oxidized[a]
Si(%)[b]	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0
Al	5	7	0.5	2	3	5	5	5
Fe	2	2	0.5	3	1.5	2	2	2
Mg	5	10	0.15	5	10	7	5	0.5
Ca	7	>10.0	0.03	7	>10.0	10	10	0.2
Na	0.05	0.1	0.03	0.05	0.1	0.07	0.03	0.07
K	1.5	3	0	1.5	1.5	2	1.5	2
Ti	0.2	0.2	0.02	0.1	0.1	0.15	0.15	0.3
P	0	0	0	0	0	2	0	0
Mn (ppm)[c]	100	150	7	150	500	150	150	10
Ag	0	0	1	0	2	0	0	0.7
As[d]	154	800	385	180	480	11,000	1,450	790
Au[e]	9	12	23	6	5	69	10	50
B	150	70	7	20	100	30	70	70
Ba	200	200	500	100	500	500	150	300
Co	7	5	0	7	3	3	3	1.5
Cr	70	70	10	30	70	70	50	100
Cu	50	20	70	30	70	50	20	30
Ga	15	15	0	7	7	10	10	20
Hg[d]	25	40	55	25	20	200	35	100
La	50	0	0	50	0	50	70	50
Mo	15	7	5	15	50	10	5	5
Nb	0	7	0	0	0	0	0	10
Ni	50	20	3	70	100	20	20	15
Pb	15	0	0	10	15	0	15	30
Sb[d,g]	<40	150	40	<40	60	115	129	360
Sc	10	15	0	7	7	10	15	15
Sr	150	0	10	100	200	150	100	100
Tl	70	200	0	0	0	150	50	0
V	200	0	70	100	700	70	50	200
W[g]	<20	<20	<20	<20	30	20	<20	<20
Y	20	30	0	15	70	20	30	30
Yb	2	1.5	0	1	3	1.5	3	3
Zn[d]	51	114	6	7	100	<5	163	65
Zr	100	150	20	100	70	150	200	300

[a]Descriptions correspond to ores from specific locations.
[b]Elements Si through P given in weight percent.
[c]Elements Mn through Zr given in parts per million.
[d]X-ray fluorescence analysis.
[e]Atomic absorption analysis.
[f]Leico mercury vapor analysis.
[g]Calorimetric analysis.

(Source: Radtke 1980.)

may occur in association with oxidation. Sulfide ores retain their original composition. Zones of secondary enrichment may form at the oxidized/unoxidized interface. A list of elemental constituents in oxide and sulfide (unoxidized) ores in the Carlin Mine is presented in Table 1-3 (Radtke 1980).

The minerals found in gold ores, and elements associated with them, vary with the type of ore. Sulfide ores contain varying amounts of native gold and silica (SiO_2), as well as sulfur-bearing minerals, including, but not limited to, sphalerite (ZnS), chalcopyrite ($CuFeS_2$), cinnabar (HgS), galena (PbS), pyrite (Fe_2S), sylvinate ($(Au,Ag)Te_2$), realgar (AsS), arsenopyrite (FeAsS), ellisite (Tl_3AsS_3), and other thallium-arsenic antimony-mercury-bearing sulfides and sulfosalt minerals. Oxide ores may contain varying amounts of these minerals, as well as silica (SiO_2), limonite ($FeO{\cdot}OH{\cdot}nH_2O$), calcite ($CaCO_3$), clay minerals, and iron oxides (Hurlbut and Klein 1977).

The mineral assemblage of the ore deposit is an important factor in selecting the beneficiation method. In general, the percent recovery of gold from sulfide ores using cyanidation is lower and more costly than for oxide ores. Recovery is reduced because the cyanide solution reacts with other constituents, such as sulfides in addition to gold, and complicates beneficiation. Increased costs are associated with the preparation of sulfide ores when they are oxidized in roasters or autoclaves (see the Beneficiation Section) (Weiss 1985). Milling, flotation, gravity concentration, and other beneficiation methods are customized to maximize recovery of precious metals from the ore deposit.

1.4 GOLD EXTRACTION AND BENEFICIATION PRACTICES

Gold operations consist of three major steps: extraction, beneficiation, and processing. Extraction is analogous to mining and is defined as removing ore material from a deposit. Four main techniques are used in the beneficiation of gold ore: cyanidation, flotation, amalgamation, and gravity concentration. The method used varies with mining operations and depends on the characteristics of the ore and economic considerations (U.S. DOI, Bureau of Mines 1984). Figure 1-1

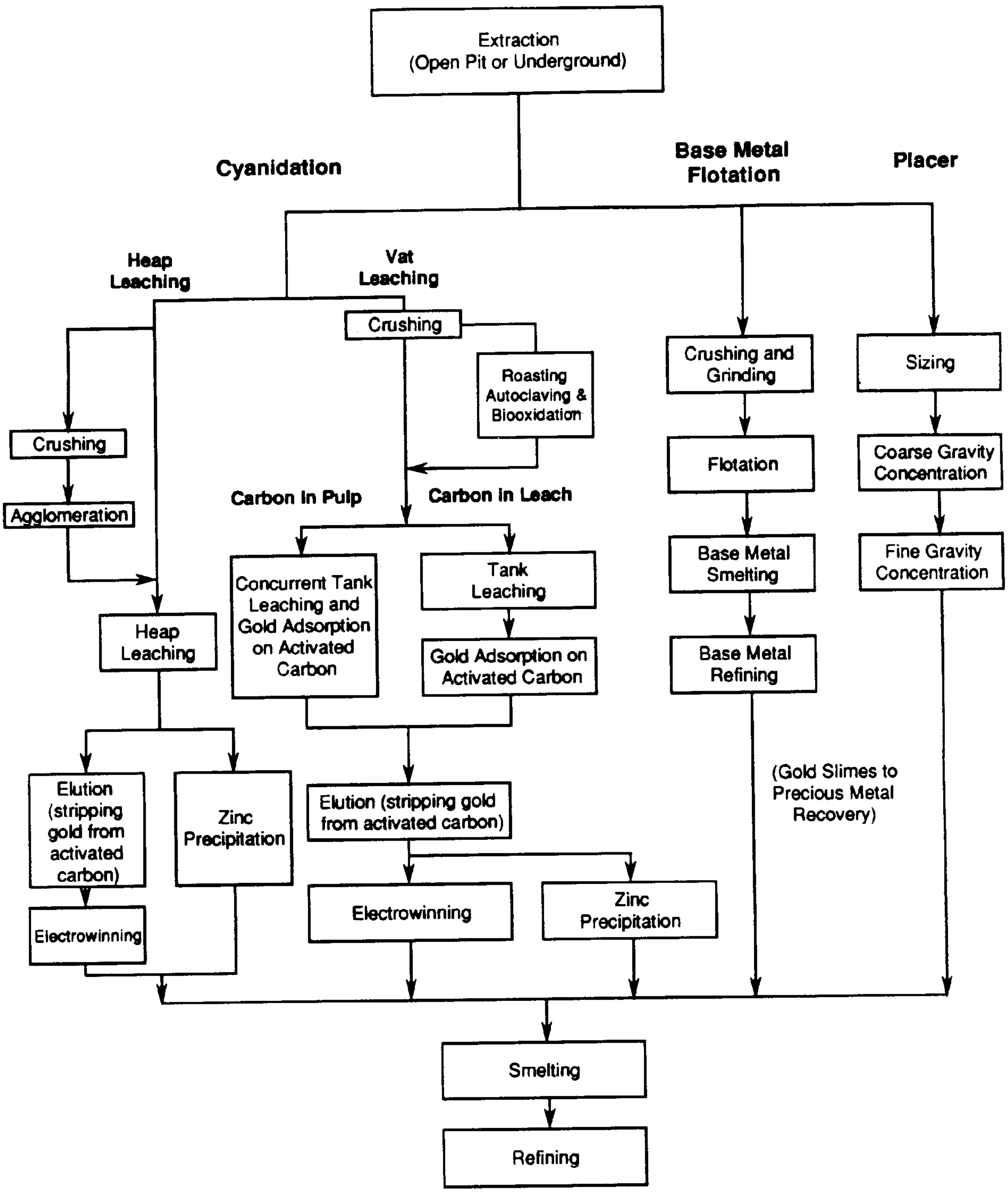


Figure 1-1. Gold Extraction and Beneficiation Overview

is a diagram of the common methods used to beneficiate gold. Because lode ore gold mines generally use cyanidation techniques, the following sections focus on cyanidation. The discussion of amalgamation is brief, since this method is of historic significance and is not in use today. Gravity concentration methods are used in placer-type operations and are discussed in a separate Technical Resource Document. Base metal flotation operations are also discussed in other Technical Resource Documents (See the Copper and Lead-Zinc Technical Resource Documents). Beneficiation flow sheets for specific mine operations are presented in Appendix 1-A.

In 1991, cyanidation and direct processing (smelting of precious metals recovered as a by-product from base metal mining) were used to generate 90 percent and 10 percent of all domestic recovered lode gold, respectively and 99 percent of all gold produced (Table 1-5, discussed later). Placer mining accounts for 1 percent of the total gold produced. Amalgamation was used to beneficiate less than 1 percent of all lode gold in 1986 (1986 was the last year for which complete data were reported concerning amalgamation) (U.S. DOI, Bureau of Mines 1990a).

1.4.1 Extraction Methods

Gold ore extraction may be conducted using either surface or underground techniques. Mining methods are selected based on maximum ore recovery, efficiency, economy, and the character of the ore body (including dip, size, shape, and strength) (Whiteway 1990).

Generally, gold mining is conducted using surface mining techniques in open-pit mines. This is primarily because of economic factors related to mining large-volume, low-grade ores and the improvement of cyanide leaching techniques. In 1988, the total of crude ore handled at surface lode mines was 160 million short tons (97.8 percent), while underground mines accounted for only 3.56 million short tons (2.2 percent) (U.S. DOI, Bureau of Mines 1991a). Table 1-4 summarizes the amount of crude ore, waste, and marketable product generated by surface, underground, and placer operations in 1988.

Table 1-4. Crude Ore, Waste, and Marketable Product at Surface and Underground Gold Mines, 1988

Material/Ratio	Surface (Lode) Short Tons (000s)	Underground (Lode) Short Tons (000s)	Total Lode Short Tons (000s)	Placer Short Tons (000s)
Material Handled	553,000	4,890	558,000	32,900
Crude Ore	160,000	3,560	163,560	15,000
Waste	394,000	1,340	395,000	17,900
Marketable Product Thousand Troy Ounces	5,250	241	5,490	153
Crude Ore to Marketable Product Ratio	21.3:1	15.7:1	21.1:1	91.5:1
Material Handled to Marketable Product Ratio	105.4:1	20.3:1	---	215.3:1

(Source: U.S. EPA, and compiled from U.S. DOI, Bureau of Mines 1990b.)

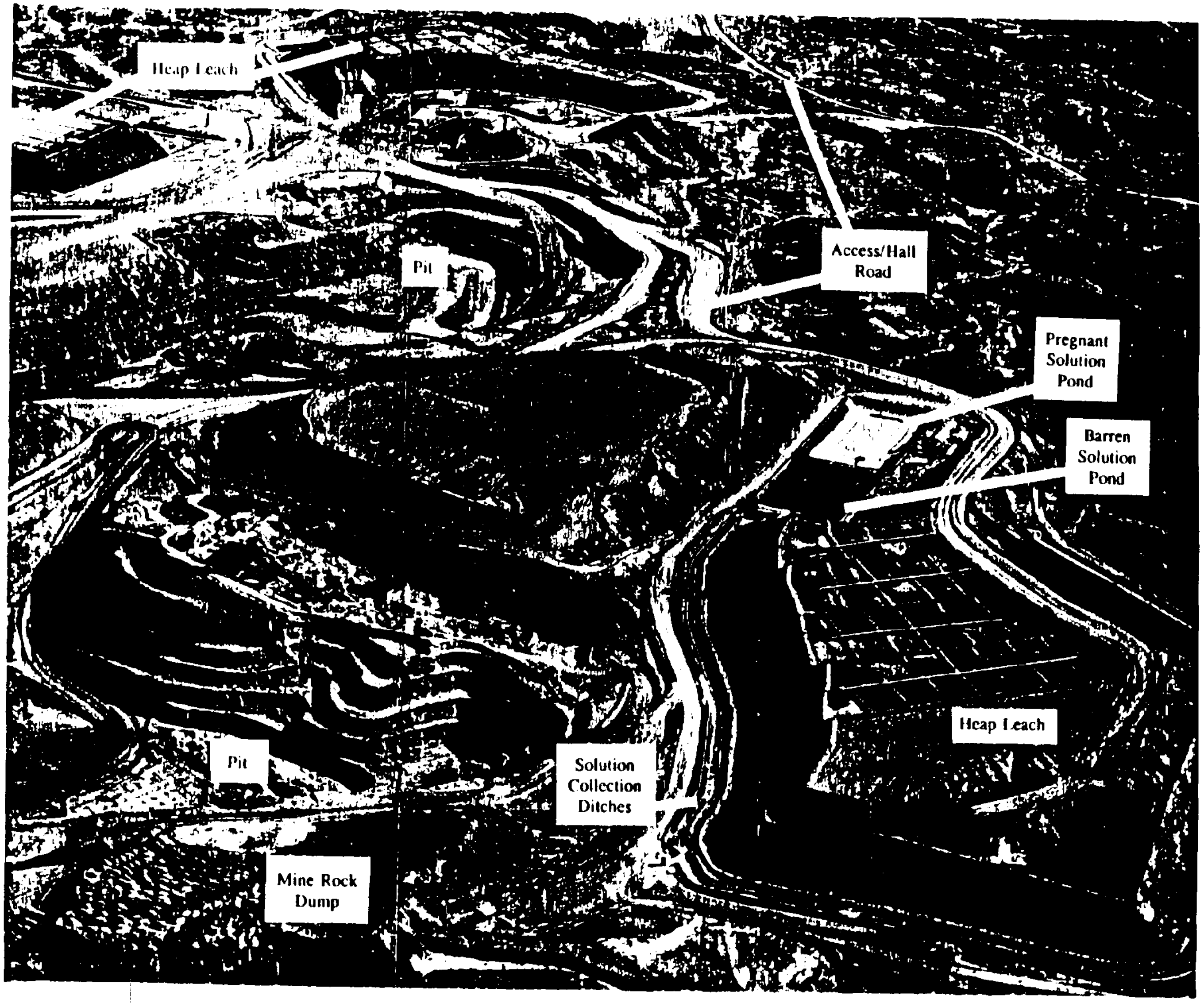
About 90 percent of the 201 active gold mines are lode-type and 10 percent are placer (U.S. DOI, Bureau of Mines 1990a). As noted previously, the top 25 gold-producing mines accounted for 68 percent of domestic production in 1991.

Surface mining methods associated with the extraction of gold include open-pit, placer, and dredge (industry often considers placer and dredge separately). Placer mining is used to mine and concentrate gold from alluvial sand and gravels. Underground mining operations use various mining methods, including caving, stoping, and room and pillar. Consolidated ore mining methods include surface and underground techniques for mining lode ore and are described below. These practices follow the basic mining cycle of drilling, blasting, and mucking.

1.4.1.1 Surface Mining

The most predominant surface mining method used to extract gold ore is open-pit. Ore containing valuable minerals usually is surrounded by less valuable material. Overburden, the unconsolidated soil and consolidated rock material overlying or adjacent to the ore body, is first removed, and the crude ore is broken and transported to the mill or directly to a heap for beneficiation activities. Overburden and development rock (sometimes referred to as innerburden if interspersed with the ore body) may be continually removed during the life of the mine as the pit walls are cut back to permit deepening of the mine.

The depth to which an ore body is mined depends on the ore grade, nature of the overburden, and the stripping ratio. The stripping ratio is the amount of overburden that must be removed for each unit of crude ore mined. Stripping ratios vary with mine site and the ore being mined. Surface mining of gold is generally more economical than underground methods, especially in cases when the ore body being mined is large and the depth of overburden covering the deposit is limited. An illustration of a typical surface mine and heap leach operation is presented in Figure 1-2. The primary advantage of


Heap Leach
Pit
Access/Hall Road
Pregnant Solution Pond
Barren Solution Pond
Heap Leach
Pit
Solution Collection Ditches
Mine Rock Dump

surface mining is the ability to move large amounts of material at a relatively low cost, in comparison with underground operations. Open-pit and open-cut mining are considered to be the least expensive extraction techniques (U.S. EPA, Office of Water, Effluent Guidelines Division 1982).

1.4.1.2 Underground Mining

In general, underground mining involves sinking a shaft or driving a drift near the ore body to be mined and extending horizontal passages (levels) from the main shaft at various depths to the ore. Mine development rock is removed, while sinking shafts, adits, drifts, and cross-cuts, to access and exploit the ore body. From deep mines, broken ore (or muck) is removed from the mine either through shaft conveyances or chutes and hoisted in skips (elevators). From shallow mines, ore may be removed by train or conveyor belt. Waste rock, mine development rock, or mill tailings may be returned to the mine to be used as fill for mined-out areas (U.S. EPA, Office of Water 1982).

1.4.2 Beneficiation Methods

As discussed above, gold beneficiation operations include cyanidation, base-metal flotation, gravity concentration (for placer deposits), and amalgamation (which is generally no longer used). Base-metal flotation, gravity concentration, and amalgamation are described only briefly below. Because most lode ore gold mines use some form of cyanidation, these techniques are the main focus of this profile. In general, there are two basic types of cyanidation operations, tank leaching and heap leaching. In addition, tank leaching involves one of two distinct types of operations, Carbon-in-Pulp or Carbon-in-Leach. In Carbon-in-Pulp operations, the ore pulp is leached in an initial set of tanks with carbon adsorption occurring in a second set of tanks. In Carbon-in-Leach operations, leaching and carbon recovery of the gold values occur simultaneously in the same set of tanks. Table 1-5 presents a comparison of gold ore treated and gold product produced by beneficiation method.

Table 1-5. Comparison of Gold Ore Treated and Gold Product by Beneficiation Method, 1991

Beneficiation Method	**Gold Ore Treated**		**Gold Product Produced**	
	Percent	**Metric Tons (000s)**	Percent	Kilograms[c]
Cyanidation (All)	51	206,610	90	259,163
Heap Leaching	36	145,441	33	94,464
Tank Leaching	14	61,168	56	161,699
Amalgamation[a]	0.5	0.85	0	1,048
Smelting (Ore and Concentrates)[b]	49	201,370	10	28,296
Total Lode	100	409,018	100	286,998
Placer	100	5.5 million cubic meters	100 (1% of total gold)	2,888

[a]Values for amalgamation for 1986 production, the last year complete information has available.
[b]Smelting of base metal ores and concentrates, mainly copper and lead ores.
[c]1 kilogram is equivalent to 32.1507 troy ounces.

(Source: U.S. DOI, Bureau of Mines 1992.)

1.4.2.1 By-Product Gold (Flotation)

Flotation is a technique in which particles of a single mineral or group of minerals are made to adhere, by the addition of reagents, preferentially to air bubbles (U.S. EPA, Office of Water 1982). This technique is chiefly used on base metal ore that is finely disseminated and generally contains small quantities of gold in association with the base metals. Gold is recovered as a byproduct of the base metal recovery. Although no production information is available specifically for flotation, U.S. Bureau of Mines personnel have suggested that production figures presented in Table 1-5 for smelting may approximate byproduct gold production by the base metal industry. In 1988, smelting recovered 0.67 million troy ounces of gold (11 percent of all domestic gold produced) (U.S. DOI, Bureau of Mines 1990a).

Ore is milled and sorted by size in preparation for flotation. The ore is then slurried with chemical reagents of four main groups: collectors (promoters), frothers, activators, and depressants. In a typical operation, the ore slurry and reagents are mixed in a conditional cell so the reagents coat the target mineral. The conditional slurry is pumped to a flotation cell, and air is injected. Air bubbles adhere to the reagents and carry the target mineral to the surface, away from the remaining gangue, for collection. In the flotation technique, the target mineral is not necessarily the precious metal or other value. Depending on the specific gravity and the reagents used, the values may be recovered from the top or bottom of the flotation cell.

1.4.2.2 Gravity Concentration

Gravity concentration techniques used most at placer mines rely on gravitational forces to suspend and transport gangue away from the heavier valuable mineral. A separate report discussing this technique at placer mines is being prepared by EPA.

1.4.2.3 Amalgamation

In amalgamation operations, metallic gold is wetted with mercury to form a solution of gold in mercury, referred to as an amalgam. This method of beneficiation is most effective on loose or free coarse gold particles with clean surfaces (U.S. EPA, Office of Water 1982). Because of its high surface tension, mercury does not penetrate into small crevices of ore particles as sodium cyanide does. Consequently, the ore must be milled finely enough to expose the gold material. In 1986, the last year for which complete statistics were provided, amalgamation operations produced 33,710 troy ounces of gold (0.5 percent of all gold produced domestically) (U.S. DOI, Bureau of Mines 1990a). Use of this method of gold beneficiation has been greatly restricted in recent times because of its high costs, inefficiency in large-scale operations, and scarcity of ores amenable to the technique.

Ore preparation consists of grinding, washing, and/or floating the ore. The ore is then fed into a ball mill along with mercury to form an amalgam. The amalgam is then passed over a series of copper plates where it collects. When fully loaded with amalgam, the plate is removed and the amalgam is scraped off. Upon heating the hardened amalgam in a retort furnace, the mercury is vaporized and the gold material remains. The mercury driven off by heating is captured, condensed, and reused. Alternatively, hot dilute nitric acid may be applied to the amalgam, dissolving the mercury and leaving the gold material. Amalgamation has traditionally been used in conjunction with other beneficiation methods such as cyanidation, flotation, and gravity concentration (Beard 1987).

Wastes generated as a result of amalgamation activities consist of gangue in the form of coarse- and fine-grained particles and a liquid mill water component in the form of a slurry. The constituents of the waste are similar to those found in the ore body (or gravel) plus any mercury lost during amalgamation. This material is sent to a tailings impoundment (U.S. DOI, Bureau of Mines 1984).

1.4.2.4 Cyanidation

The predominant method used to beneficiate gold ore is cyanidation. This technique uses solutions of sodium or potassium cyanide as lixiviants (leaching agents) to extract precious metals from the ore. Cyanide heap leaching is a relatively inexpensive method of beneficiating low-grade gold ores while tank leaching is used for higher grade ore. In 1988, cyanidation operations (including both heap leaching and tank operations) treated 146.7 million short tons of gold ore and recovered 5.6 million troy ounces of gold (U.S. DOI, Bureau of Mines 1990a). This represented 90 percent of all lode gold produced from all beneficiation methods.

Although other lixiviants are currently being tested, none are known to be used in commercial operations. Alternative lixiviants include malononitrile, bromine, urea, and copper-catalyzed thiosulfate (U.S. DOI, Bureau of Mines 1985; U.S. DOI, Bureau of Mines, undated(a)). Bromine, for example, is being promoted as an alternative to cyanide by the Great Lakes Chemical Corporation. However, only pilot plant tests are known of at this time (Dadgar 1989; Winegar 1991).

Cyanidation techniques used in the gold industry today include heap or valley fill leaching followed by carbon adsorption (carbon-in-column adsorption), agitation leaching followed by carbon-in-pulp (CIP), or agitated carbon-in-leach (CIL). *In situ* leaching of gold is being researched by the Bureau of Mines, but is not used commercially at this time. Cyanidation is best suited to fine-grain gold in disseminated deposits. Heap or valley fill leaching is generally used to beneficiate ores containing less than 0.04 oz/t. CIP and CIL techniques, commonly referred to as tank or vat methods, are generally used to beneficiate ores containing more than 0.04 oz/t. These gold beneficiation cut-off values are dependent on many factors, including the price of gold and an operation's ability to recover the precious metal (van Zyl et al. 1988).

For this discussion, cyanidation-carbon adsorption is considered in four steps: leaching, loading, elution, and recovery (van Zyl et al. 1988) (see Figure 1-3

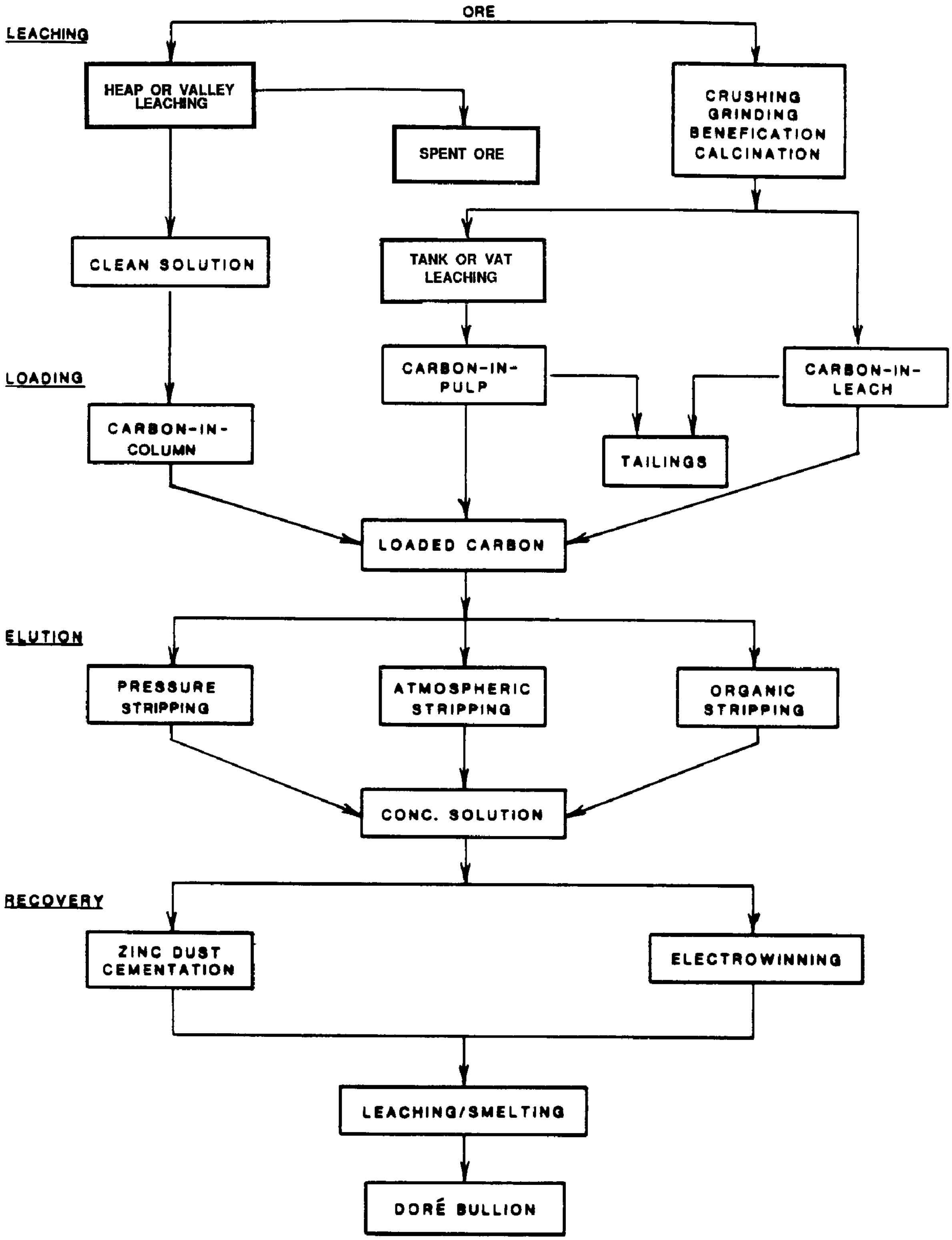


Figure 1-3. Flowsheet for Recovery of Gold Using Carbon Adsorption

(Source: Van Zyl, et al. 1988.)

). In leaching, the cyanide reacts with the ore to liberate gold material and form a cyanide-gold complex in an aqueous solution. Precious metal values in solution are loaded onto activated carbon by adsorption. When the loading is complete, the values are eluted, or desorbed from the carbon, and recovered by electrowinning or zinc precipitation, prior to smelting.

An alternative to cyanidation/carbon adsorption is cyanidation/zinc precipitation. The cyanidation-zinc precipitation technique is also presented in four steps: leaching, clarification, deaeration, and precipitation. The precipitate (a solid) is smelted directly. A full description of activated carbon adsorption and zinc precipitation follows the discussion of heap leaching. Other methods to separate the precious metal from the pregnant solution include solvent extraction and direct electrowinning; these methods are not common in the industry and are not discussed in this profile.

Depending on the type of ore (sulfide or oxide), the gold concentration in the ore, and other factors, the mine operator may prepare the ore by crushing, grinding and/or oxidation (roasting, autoclaving, or bio-oxidation) prior to cyanidation or flotation. In some cases, low grade ore is loaded directly onto heap leach pads with little or no preliminary ore preparation. This practice transports run-of-mine ore directly to the pad for leaching. In most other cases, the ore is crushed and/or ground, prior to leaching or flotation. Each of the steps involved in beneficiation is described in detail in the following sections.

Ore Preparation

Crushing and Grinding

Beneficiation begins with the milling of extracted ore in preparation for further activities to recover the gold values. Milling operations are designed to produce uniformly sized particles by crushing, grinding, and wet or dry classification. Economics play a large part in determining the degree of grinding or crushing performed to prepare the ore. Other factors include the gold concentration of the ore, the mineralogy and hardness of the ore, the mill's capacity, and the next planned step in the beneficiation of the ore. Run-of-mine ores with very low gold concentrations may be sent directly to a heap leach pile.

Milling begins when ore material from the mine is reduced in particle size by crushing and grinding. A primary crusher, such as a jaw type, is used to reduce ore into particles less than 150 millimeters (about 6 inches) in diameter. Generally, crushing continues using a cone crusher and an internal sizing screen until the ore is less than 19 mm (3/4 inch). Crushing in jaw and cone crushers is a dry process, with water spray applied only to control dust. From the cone crusher, ore is fed to the grinding circuit where milling continues in the presence of water. Water is added to form a slurry containing 35 to 50 percent solids. Grinding in ball or rod mills further reduces the ore particle size, as needed. In some cases, ore and water are fed directly into an autogenous mill (where grinding media are the hard ore itself); or, a semiautogenous mill (where the grinding media are the ore supplemented by large steel balls). Between each grinding unit operation, hydrocyclones are used to classify coarse and fine particles. Coarse particles are returned to the mill for further size reduction. Milled ore is in the form of a slurry, which is pumped to the next unit operation

(Weiss 1985; Stanford 1987). Fugitive dust generated during crushing and grinding activities is usually collected by air pollution control device blowdown streams and is generally recirculated into the beneficiation circuit. Most mills use water sprays to control dust from milling activities.

Oxidation of Sulfides (Roasting, Autoclaving, and Bio-Oxidation)

After milling, beneficiation of sulfide ores may include oxidation of sulfide minerals and carbonaceous material by roasting, autoclaving, bio-oxidation, or chlorination.[1] Roasting involves heating sulfide ores in air to convert them to oxide ores. In effect, roasting oxidizes the sulfur in the ore generating sulfur dioxide that can be captured and converted into sulfuric acid. Roasting temperatures are dependent on the minerology of the ore, but range as high as several hundred degrees Celsius. Roasting of ores that contain carbonaceous material oxidizes the carbon to prevent interference with leaching and reduced gold recovery efficiency. Autoclaving (pressure oxidation) is a relatively new technique that operates at lower temperatures than roasting. Autoclaving uses pressurized steam to start the reaction and oxygen to oxidize sulfur-bearing minerals. Heat released from the oxidation of sulfur sustains the reaction. The Getchell and Barrick Goldstrike Mines in Nevada, the McLaughlin Mine in California, and the Barrick Mercur Mine in Utah are currently using pressure oxidation (autoclave) technology, totally or in part, to beneficiate sulfide or carbonaceous gold ores.

Bio-oxidation of sulfide ores employs bacteria to oxidize the sulfur-bearing minerals. This technique is currently used on an experimental basis at the Congress Gold Property in Canada and at the Homestake Tonkin Springs property in Nevada. The bacteria used in this technique are naturally occurring and typically include *Thiobacillus ferrooxidans, Thiobacillus thiooxidans, and Leptospirillum ferrooxidans*. In this technique, the bacteria are placed in a vat with sulfide gold ore. The bacteria feed on the sulfide minerals and ferrous iron components of the gold ore. Research is currently being conducted on other bacteria that can grow at higher temperatures; high-temperature bacteria are thought to treat the ore at a much faster rate (U.S. DOI, Bureau of Mines 1990a). Although more time is required for bio-oxidation, it is considered to be less expensive than roasting or autoclaving (Hackel 1990).

Agglomeration

Ores with a high proportion of small particle size (minus 200 mesh) require preparation before leaching can be done effectively. Because percolation of the lixiviant may be retarded as a result of blocked passages by fine-grained particles, these types of ores are agglomerated to increase particle size. Agglomeration is the technique of aggregating individual particles into a larger mass, thus enhancing percolation of the lixiviant and extraction efficiency. This technique may increase the flow of cyanide solution through the heap by a factor of 6,000, decreasing the overall leaching time needed. Agglomeration is currently used in half of all

[1] Chlorination is not commonly used to oxidize sulfide ores because of the high equipment maintenance costs caused by the corrosive nature of the oxidizing agent.

heap leaching operations. The agglomeration technique typically involves (U.S. DOI, Bureau of Mines 1986) the following:

- Mixing the crushed ore with portland cement (a binding agent) and/or lime (to provide alkalinity)
- Wetting the ore evenly with cyanide solution to start leaching before the heap is built
- Mechanically tumbling the ore mixture so fine particles adhere to the larger particles.

Heap Leaching

In the past 13 years, heap leaching has developed into an efficient way to beneficiate a variety of low-grade, oxidized gold ores. Compared to conventional cyanidation (i.e., tank agitation leaching), heap leaching has several advantages, including simplicity of design, lower capital and operating costs, and shorter startup times. Depending on the local topography, a heap or a valley fill method may be employed. Where level ground exists, a heap is constructed; in rough terrain, a valley may be dammed and filled. The design of these leaching facilities and their method of operation are site-specific and may even vary over time at the same site. Typically, heaps are constructed of lower-grade oxidized ores. Depending on the type of ore, it may be sent directly to the heap (run-of-mine ore), crushed, or agglomerated to maximize gold recovery. Recovery rates for heap and valley fill leaching range from 60 to 80 percent. Prior to constructing a heap, a pad and an impermeable liner are built to collect the leachate. A diagram of a typical heap leaching system is presented in Figure 1-4

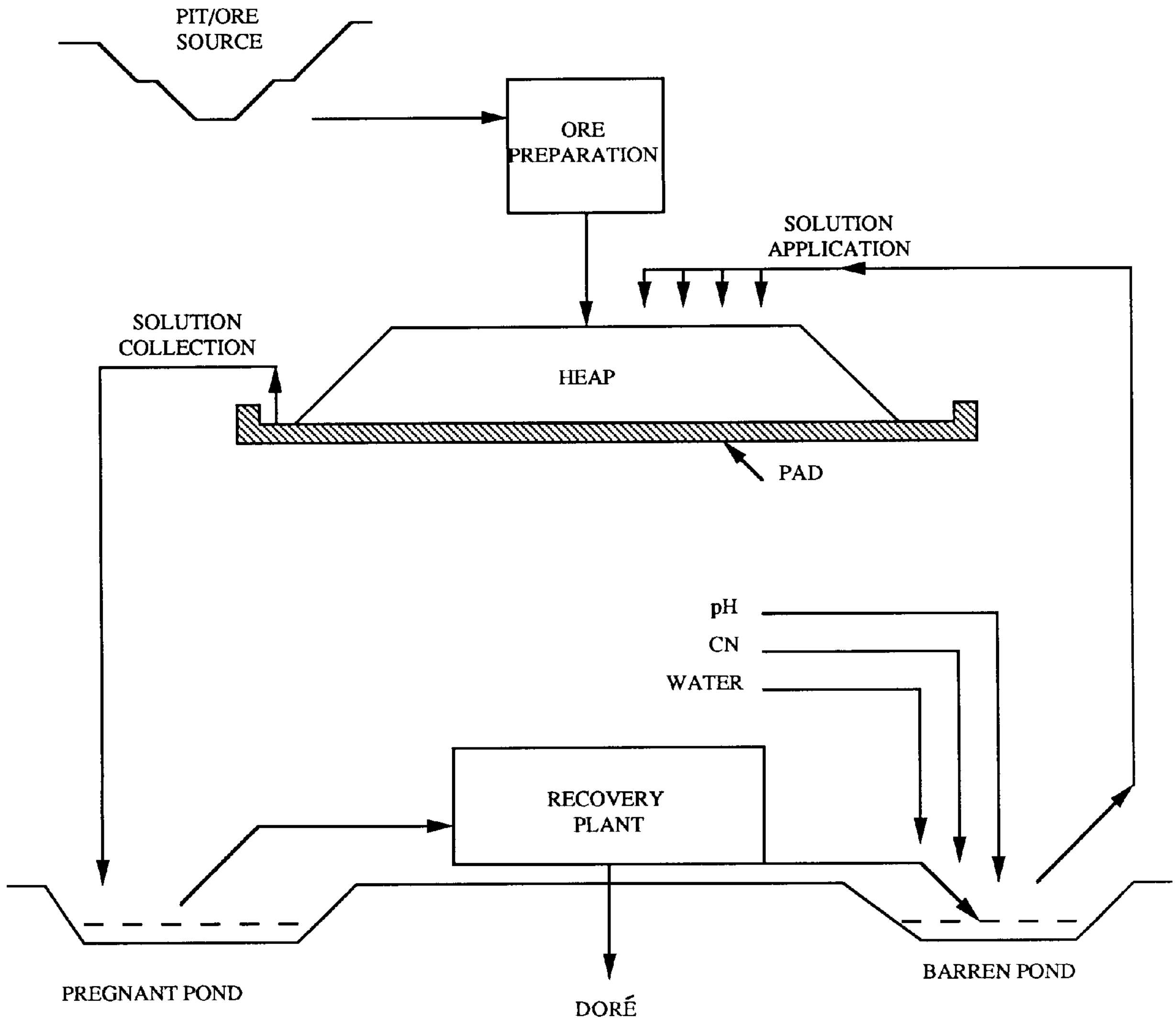


Figure 1-4. Typical Heap Leaching System

(Source: U.S. DOI, Bureau of Mines 1984.)

. This method is frequently applied to run-of-mine ore on which minimal or no crushing is performed.

Statistics generated by the Bureau of Mines group gold production from heap and dump leaching together. (Dump leaching is typically conducted on base metal ores from which byproduct gold may be recovered.) Currently, no gold heap or valley fill leaches are known to operate without a liner (Hackel 1990). The use of a liner in gold heap leaching operations may prevent the loss of gold values. In 1988, according to the Bureau of Mines, heap and dump leach operations treated 102.2 million metric tons of gold ore and recovered 2.3 million troy ounces of gold (U.S. DOI, Bureau of Mines 1990a). This represented 37 percent of all lode gold produced and 42 percent of all gold produced by cyanidation (see Table 1-5).

Heap leaching activities may involve some or all of the following steps (U.S. DOI, Bureau of Mines 1978, 1984):

- Preparation of a pad with an impervious liner on a 1° to 6° slope or greater for drainage, and extracting ore from the mine site (or alternatively gathering ore from waste piles)
- Crushing and/or agglomeration of the ore to between 1/2 and 1 inch in size if necessary and cost effective; some operations may leach run-of-mine ore (the agglomeration technique will be discussed later in this section)
- Placing the ore on the pad(s) using trucks, bulldozers, conveyor belts, or other equipment
- Applying cyanide solution using drip, spray, or pond irrigation (generally between 0.5 and 1.0 pounds of sodium cyanide per ton of solution)
- Collecting the solution via ditches, piping, ponds, and/or tanks.

Two common types of pads used in gold heap leaching include permanent heap construction on a pad from which the leached ore is not removed; and on-off pads, which allow leached ore pile to be removed following the leach cycle. Permanent heaps are built in lifts composed of 5- to 30-foot layers of ore added to the top of the heap. On-off pads are used to a limited extent in the industry and are constructed to allow spent ore to be removed after the leaching cycle (Lopes and Johnston 1988).

Pad and liner construction methods and materials vary with the type of pad and site conditions. Construction materials may include compacted soil or clay, asphaltic concrete, and low-permeability synthetic membranes such as plastic or geomembrane (see Figure 1-5

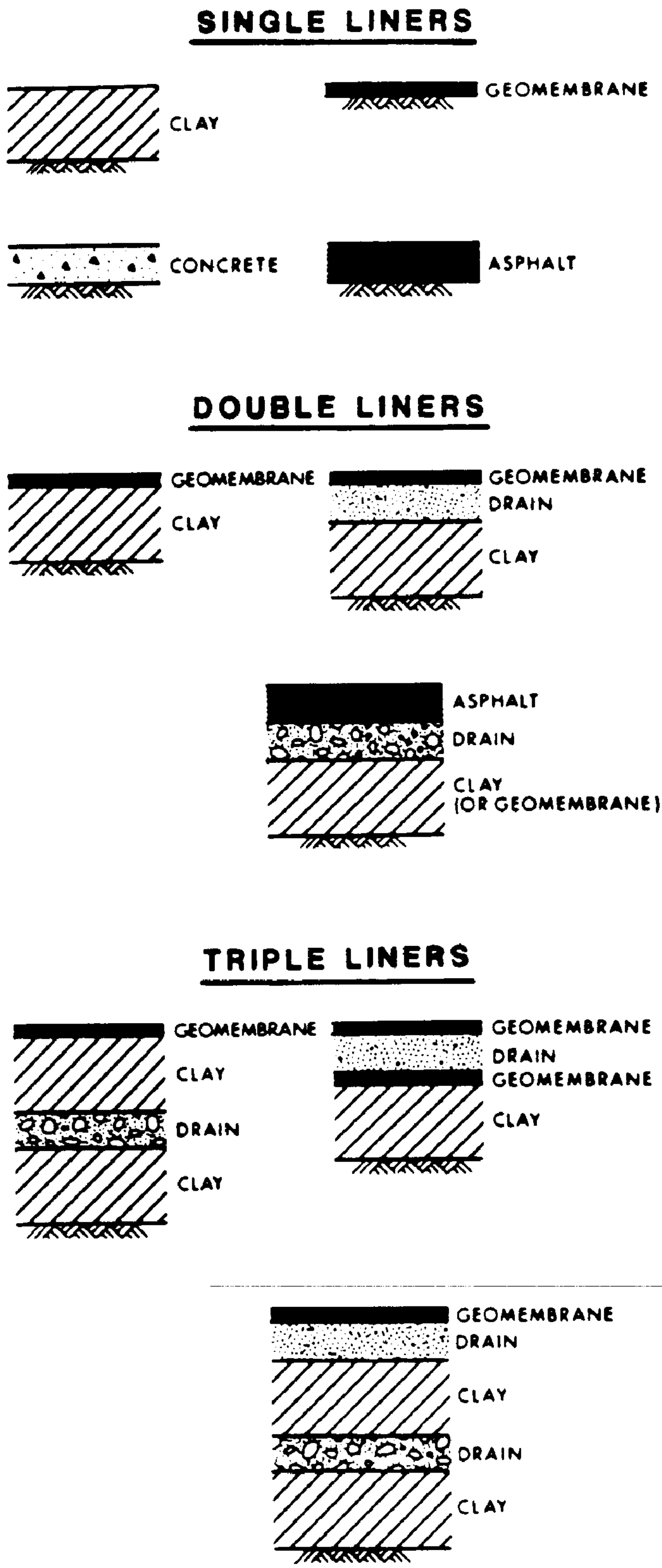


Figure 1-5. Typical On-Off and Life Pad Liner Construction Materials

(Source: Van Zyl, D.J.A., et al. 1988.)

) (van Zyl et al. 1988). Sand or crushed ore may also be used on top of the synthetic liner to aid in leachate collection and protect the pad. Older pads tend to be made of compacted clay. Newer pads are usually constructed of synthetic materials, typically installed over a compacted layer of native soil or imported clay. Some mines use synthetic liners composed of high-density polyethylene (HDPE) or very low-density polyethylene (VLDPE) in combination with compacted native materials. These liner systems are referred to as composite liners. On-off pads are generally constructed of asphaltic concrete to protect the liner from potential damage by heavy machinery used during unloading. The risk that a liner system will leak is most acute during mine operation when ore is added to the heap and fluids place pressure on it.

When all beneficiation ends and the heap or valley fill unit is reclaimed, the operator typically controls fluid movement to the liner by installing run-on/runoff controls and other measures.

A variation of heap leaching is valley fill leaching (Eurick 1991). This method is used at facilities with little or no flat land and utilizes liner systems similar to those used in heap leaches for solution containment. In valley fill leaching, the ore material is placed on top of a liner system located behind a dam on the valley floor. As in heap leaching, the ore is treated with lixiviant but is contained and collected internally at the lowest point in the ore on the liner system for further beneficiation, rather than in an external solution collection pond. Montana, Utah, and other States have approved valley fill operations.

In these leaching operations, cyanide complexes with gold and other metals as the liquid percolates through the ore. Because percolation efficiency may be a limiting factor in heap leaching methods, some operations treat higher-grade ore with cyanide solution during primary crushing. Fine-grained ore may be agglomerated to increase permeability; this is discussed in the next section. Leaching typically takes from weeks to several months, depending on the permeability and size of the pile. An "average/normal" leach cycle takes approximately 3 months (Lopes and Johnston 1988).

The reaction of the solution with the free gold is oxygen-dependent. Therefore, the solution is oxygenated prior to application or during spraying. The cyanide leachate percolates through the ore and is collected by pipes located under the pile or carried directly to ditches around the pile (U.S. DOI, Bureau of Mines 1986; Lopes and Johnston 1988). The solution is then collected in a pond or tank. The solution pond may be used as a holding pond, a surge pond, or a settling basin to remove solids contained in the cyanide solution. Some mine operations use an alternative series of ponds, including one for the barren solution, an intermediate solution pond, and a pregnant solution pond. The intermediate solution is passed through a new pile for further enrichment to form the final, or pregnant, solution (U.S. DOI, Bureau of Mines 1984).

These ponds may be single lined but are now more often double lined with plastic (HDPE), butylrubber, and/or bentonite clay to prevent seepage. To control wildlife access to cyanide solution, some mining operations have elected to construct tanks to collect and store leachate solutions (as an alternative to open ponds). For example, the Castle Mountain Project in Barnwell, California, will collect pregnant solution in three 250,000-gallon sealed tanks (U.S. DOI, Bureau of Land Management, Needles Resource Area 1990).

Those active operations using ponds to store cyanide solutions may fence or cover the solution ponds with screening or netting in an effort to prevent wildlife or waterfowl access, respectively.

Leaching occurs according to the following reactions, with most of the gold dissolving in reaction 2 (van Zyl et al. 1988):

- $4Au + 8NaCN + O_2 + 2H_2O \rightarrow 4NaAu(CN)_2 + 4NaOH$ (Elsener's Equation and Adamson's 1st Equation)
- $2Au + 4NaCN + O_2 + 2H_2O \rightarrow 2NaAu(CN)_2 + H_2O_2 + 2NaOH$ (Adamson's 2nd Equation)

Leaching is generally effective at a pH of 9.5 to 11, with the optimum being approximately 10.5. More acidic conditions may result in the loss of cyanide through hydrolysis, reaction with carbon dioxide, or reaction with hydrogen to form hydrogen cyanide (HCN). Alternatively, more basic conditions tend to slow the reaction process (U.S. DOI, Bureau of Mines 1984). Typically, the recovered cyanide solution contains between 1 and 3 ppm of gold material (U.S. DOI, Bureau of Mines 1986). Irrigation of the heap stops when the pregnant solution falls below 0.005 ounces of gold per ton of solution (Lopes and Johnston 1988). After the leaching cycle has been completed, the heap or valley fill unit can be rinsed with mine water or mill waste water to remove most of the remaining cyanide solution and gold-cyanide complex. Cyanide in the rinse water may be detoxified using several methods, such as the addition of hydrogen peroxide or sulfur dioxide.

Wastes remaining following the conclusion of heap and valley fill leaching operations include spent ore in the piles or spent ore disposed of elsewhere on site in the case of on-off heap leach pads. The spent ore will contain small quantities of spent cyanide solution, waste water from rinsing the ore, residual cyanide, and unrecovered gold-cyanide complex.

It is estimated that, in 1980, the gold industry generated 3 million metric tons of heap leach wastes. This rose to 11 million metric tons in 1982, because of increased use of leaching as a result of rising gold prices and increased gold production (U.S. EPA 1985). Based on 1988 Bureau of Mines estimates, 102.3 million metric tons of ore were treated by heap and dump leaching to produce 2.3 million troy ounces (72.7 metric tons) of gold. After leaching is complete, 102.3 million metric tons of spent ore were or will be generated (less the volume of gold removed). These wastes will be discussed in the Extraction and Beneficiation Wastes Section.

Recovery of gold from the pregnant solution generated by heap leaching is accomplished using carbon adsorption or direct precipitation with zinc dust (known as the Merrill-Crowe process). These techniques may be used separately or in a series with carbon adsorption followed by zinc precipitation. Both carbon adsorption and zinc precipitation separate the gold-cyanide complex from the noncomplexed cyanide and other remaining wastes, including water and spent ore. Unconventional techniques used to recover gold values include solvent extraction, direct electrowinning, and, more recently, ion exchange resin.

Sources examined for this report disagree as to the relative cost efficiency of each method. Because of the low cost of zinc, gold concentration by zinc precipitation may cost less than activated carbon adsorption/ electrowinning (U.S. DOI, Bureau of Mines 1986). Activated carbon requires additional capital expenditures for a stripping plant, electrowinning, and a kiln to reactivate carbon for use in future beneficiation. On the other hand, carbon adsorption is both more efficient and less expensive, in terms of capital and operational costs, than zinc precipitation (U.S. DOI, Bureau of Mines 1978). Activated carbon techniques also are better able to process solutions with low metal concentrations and are thus most often used on solutions with a gold concentration below 0.05 oz/t of solution (U.S. DOI, Bureau of Mines 1978, 1984). Carbon-based and zinc precipitation methods are described in more detail below.

Carbon Adsorption (Carbon-in-Column/Gold Recovery)

In heap leaching carbon adsorption uses the Carbon-in-Column (CIC) technique. In the CIC technique, the pregnant solution collected from the leach pile is pumped from a collection pond or tank into a series of cascading columns containing activated carbon. The solution mixes with the carbon column in one of two methods: fixed-bed or fluid-bed.

The fluid-bed method involves pumping pregnant solution upward through the column at a rate sufficient to maintain the carbon bed in a fluid state moving gradually down through the column without allowing the carbon to be carried out of the system. Thus, loaded carbon can be removed from the bottom of the tank and fresh carbon added at the top. The fluid-bed method is the more common of the two methods used in operations adsorbing gold-cyanide values from unclarified leach solutions containing minor amounts of slimes. Because the fluid-bed method uses a countercurrent operating principal, it is often more efficient and economical than the fixed-bed method in adsorbing the gold-cyanide complex from solution (U.S. DOI, Bureau of Mines 1978, 1984).

In the fixed-bed method, the gold-laden cyanide solution is pumped downward through a series of columns. The columns generally have either flat or dished heads and contain a charcoal retention screen as well as a support grid on the bottom. Normally, the height-to-diameter ratio of the tanks is 2:1, although, in some instances, a larger ratio will increase the adsorption capacity of the system (see Figure 1-6

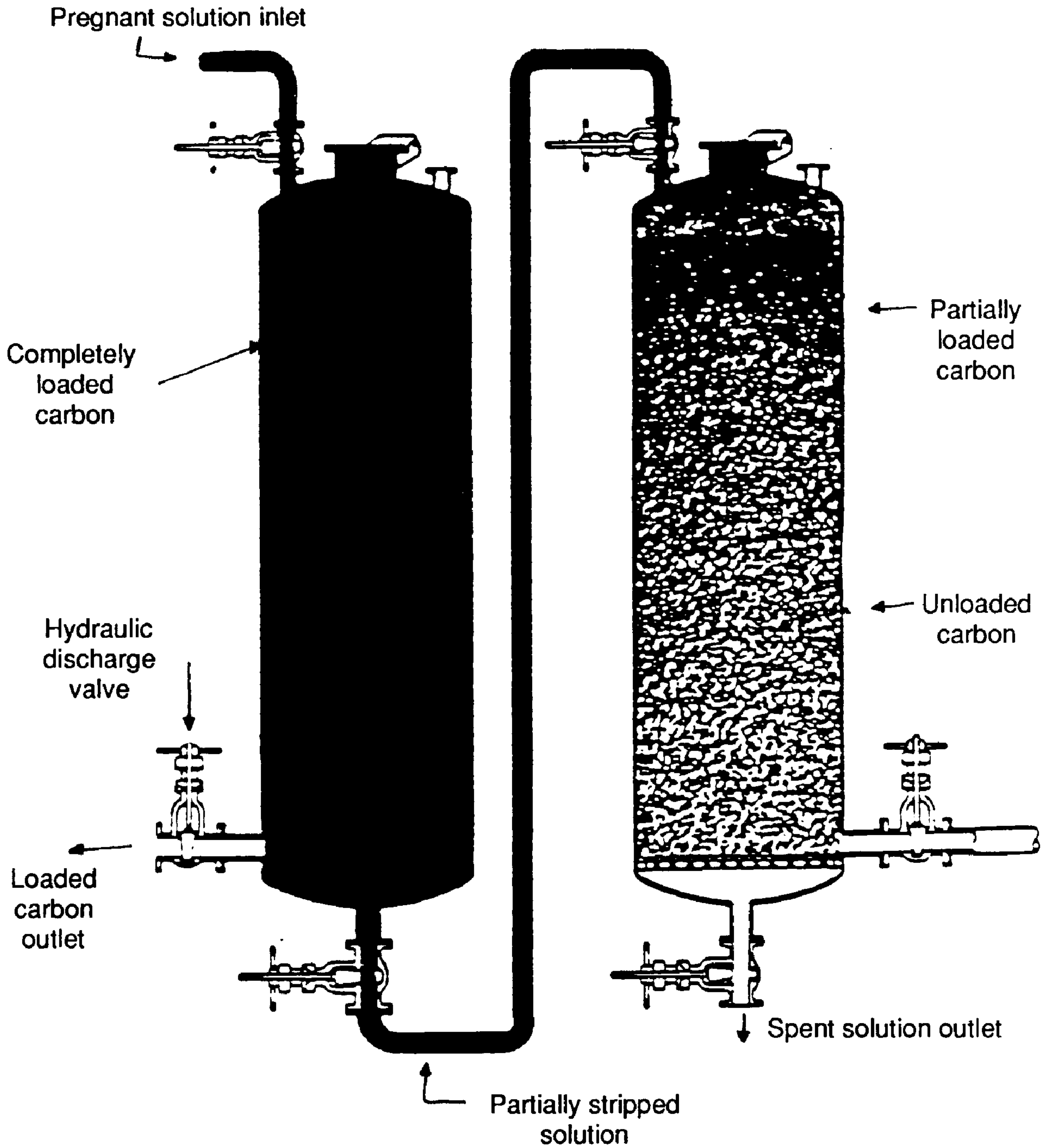


Figure 1-6. Typical Fixed-Bed Multiple Carbon-In-Column Operation

(Source: Society of Mining Engineers, Mineral Processing Handbook 1985.)

) (Weiss 1985).

In each vessel, the gold-cyanide complex is adsorbed onto activated carbon granules that preferentially adsorb the gold-cyanide complex from the remaining solution as the material flows from one column to the next. The advantage of the fixed-bed method over the fluid-bed method is that it requires less carbon to process the same amount of solution (U.S. DOI, Bureau of Mines 1978, 1984). Typically,

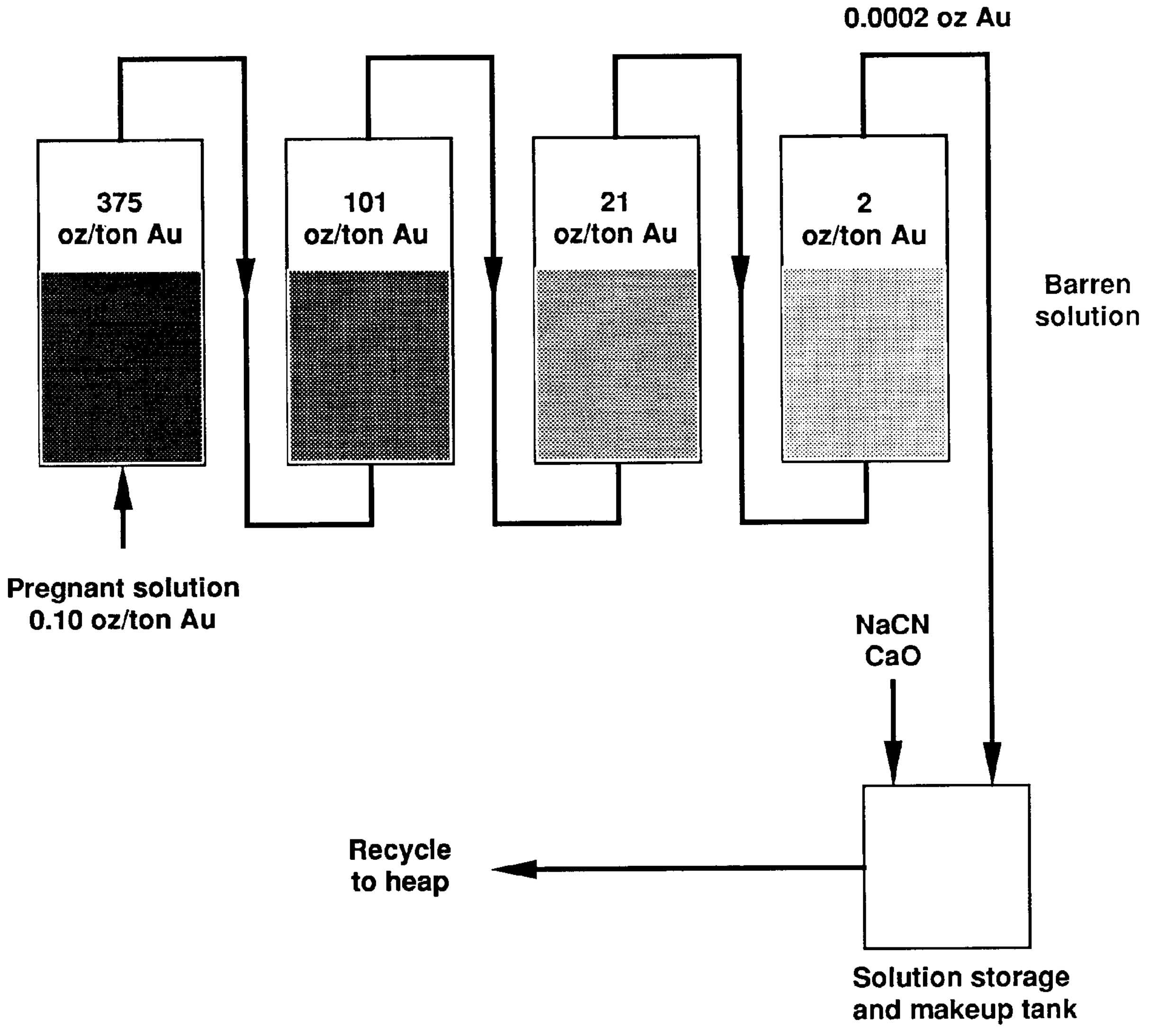


Figure 1-7. Hypothetical Distribution of Gold in a Continuous Carbon Adsorption Operation

(Source: U.S. DOI, Bureau of Mines 1978.)

the activated carbon collects gold from the cyanide leachate until it contains between 100 and 400 ounces of gold per ton of carbon depending on the individual operation (see Figure 1-7). Loading efficiency decreases with solutions containing less gold (U.S. DOI, Bureau of Mines 1978).

The precious metals are then stripped from the carbon by elution. The values can be desorbed from the carbon using a boiling caustic cyanide stripping solution (1.0 percent NaOH and 0.1 percent NaCN). Modifications of this method include the addition of alcohol to the stripping solution and/or stripping under elevated pressure or temperature (40°C to 150°C) (U.S. DOI, Bureau of Mines 1986). At the Barneys Canyon Mine, a stripping solution of hot sodium hydroxide is used. At this facility, that solution has been tested and shown to be as effective as stripping solutions containing caustic cyanide (LeHoux and Holden 1990).

After stripping, the carbon is reactivated on or off site and recirculated to the adsorption circuit (U.S. DOI, Bureau of Mines 1985). This activated carbon is washed with a dilute acid solution (pH of 1 or 2) to dissolve carbonate impurities and metal-cyanide complexes that adhere to the carbon along with the gold. This technique may be employed either immediately before or after the gold-cyanide complex is removed (Eurick 1991). Acid washing before the gold is removed enhances gold recovery. The Barrick Mercur Mine in Utah, the Barrick Goldstrike Mine in Nevada, and the Ridgeway Gold Mine in South Carolina are examples of facilities using acid prewash techniques, while the Golden Sunlight Mine in Montana and the Battle Mountain Mine in Nevada use acid postwash techniques (see the Mercur Mine flow sheet in Appendix 1-A).

Based on impurities to be removed from the carbon and metallurgical considerations, different acids and concentrations of those acids may be used. Usually, a hydrochloric acid solution is circulated through 3.6 metric tons (4 short tons) of carbon for approximately 16 to 20 hours. Nitric acid is also used in these types of operations, but is thought to be less efficient than hydrochloric acid (HCL) in removing impurities. The resulting spent acid wash solutions may be neutralized with a high-pH tailings slurry, dilute sodium hydroxide (NaOH) solution, or water rinse. When the wash solution reaches a stable pH of 10, it is sent to a tailings impoundment. Metallic elements may also be precipitated with sodium sulfide (Smolik et al. 1984; Zaburunov 1989).

The carbon is screened to remove fines and thermally reactivated in a rotary kiln at about 730°C for 20 minutes (Smolik et al. 1984). The reactivated carbon is subsequently rescreened and reintroduced into the recovery system. Generally, about 10 percent of the carbon is lost during the process because of particle abrasion. Recirculating the carbon material gradually decreases performance in subsequent adsorption and reactivation series. Carbon adsorption efficiency is closely monitored and fresh carbon is added to maintain efficiency at design levels (U.S. DOI, Bureau of Mines 1984, 1986).

The pregnant eluate solution containing gold may undergo electrowinnning or zinc precipitation. Electrowinning (or electrodeposition) uses stainless or mild steel wool, or copper as a cathode to collect the gold product. The Golden Sunlight Mine in Montana uses 3.6 kilograms (kg) [8 pounds (lb.)] of steel wool in eight cathodes within rectangular electrowinning cells. A 2.5-volt current is used to 250 amperes per cell during the operation (Smolik et al. 1984). After two cycles of electrodeposition, the steel wool must be removed and replaced. The depleted stripping solution may then be reheated and recycled to the carbon stripping system. The steel wool or electrowinning sludge, laden with gold value, is fluxed with sodium nitrate, fluorspar, silica, and/or sodium carbonate and melted in a crucible furnace for casting into bullion. For gold ores containing mercury, a retort step is required before gold smelting to recover metallic mercury (U.S. DOI, Bureau of Mines 1986; Smolik et al. 1984). Zinc precipitation is described below.

Zinc Precipitation (Merrill-Crowe)/Gold Recovery

Although carbon adsorption is the most common method of gold recovery in the United States, zinc precipitation is the most widely used method for gold ore containing large amounts of silver. Because of its simple and efficient operation, the Merrill-Crowe process is used at the 10 largest gold producing mines in the world, all of which are in South Africa. This technique is well suited to new mines where the ore has a high silver to gold ratio (from 5:1 to 20:1) (van Zyl et al. 1988).

In zinc precipitation operations, the pregnant solution (or the pregnant eluate stripped from the activated carbon) is filtered using clarifying filters coated with diatomaceous earth to aid in the removal of suspended particles (see Figure 1-8

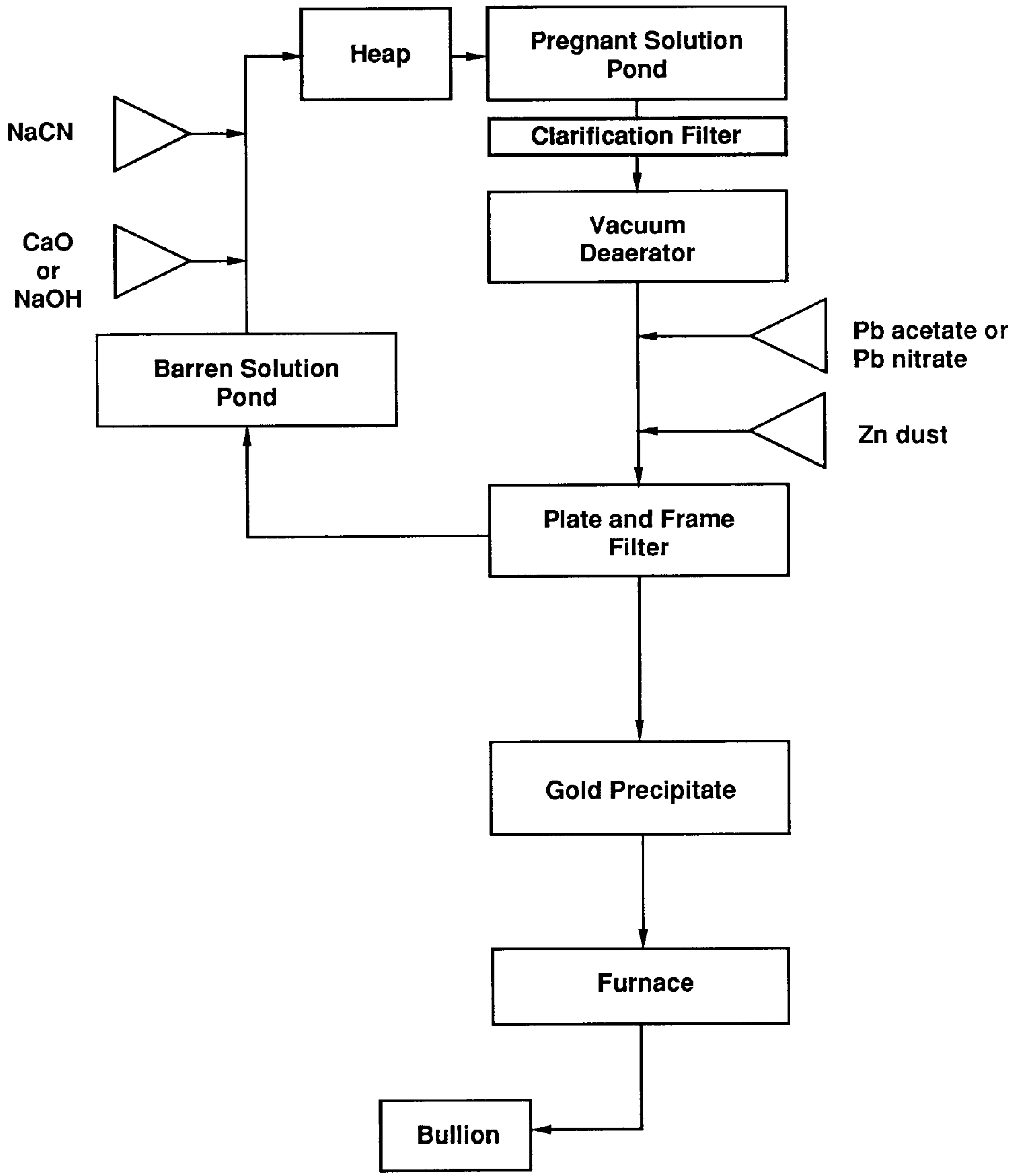


Figure 1-8. Merrill-Crowe Recovery System

(Source: Van Zyl, et al. 1988.)

) (Weiss 1985). Dissolved oxygen is then removed from the solution using vacuum tanks and pumps. This is necessary because the presence of oxygen in the solution inhibits recovery (U.S. DOI, Bureau of Mines 1984).

Metallic zinc dust then is combined with the deoxygenated pregnant solution. At some operations, a small amount of cyanide solution and lead nitrate or lead acetate is added. Lead increases galvanic activity and makes the reaction proceed at a faster rate. Zinc precipitation proceeds according to the reaction described below; the result is a gold precipitate (U.S. DOI, Bureau of Mines 1984).

$$NaAu(CN)_2 + 2NaCN + Zn + H_2O \rightarrow Na_2Zn(CN)_4 + Au + H + NaOH.$$

The solution is forced through a filter that removes the gold metal product along with any other precipitates. Several types of filters may be used, including submerged bag, radial vacuum leaf, or plate-and-frame. The gold precipitate recovered by filtration is often of sufficiently high quality (45 to 85 percent gold) that it can be dried and smelted in a furnace to make doré (unrefined metals). In cases where further treatment is necessary, the precipitate may be muffle roasted or acid treated and calcined with borax and silica before smelting (Weiss 1985). Following filtration, the barren solution can be chemically treated (neutralized) or regenerated and returned to the leach circuit (Weiss 1985).

Tank Leaching

In tank leaching operations, primary leaching takes place in a series of tanks, frequently located in buildings rather than in outdoor heaps or dumps. Finely ground gold ore is slurried with the leaching solution in tanks. The resulting gold-cyanide complex is then adsorbed on activated carbon. Carbon-in-Pulp (CIP) conducts the leaching and recovery operations in two separate series of tanks, while Carbon-in-Leaching (CIL) conducts them in a single series. The pregnant carbon then undergoes elution, followed either by electrowinning or zinc precipitation, as described previously. The recovery efficiencies found at tank operations are significantly higher than those found at heap leach facilities. Tank methods recover from 92 to 98 percent of the gold contained in the ore.

Continuous countercurrent decantation (CCD) is a method of washing the solution containing metal values from the leached ore slurry to produce a clear pregnant solution. This procedure is used for ores with high silver values that preclude the use of activated carbon and that are very difficult to filter, thus precluding the use of filters. The resulting pregnant solution is generally treated by the zinc precipitation technique.

A new technology employed in South Africa uses ion exchange resin in place of carbon in the CIP technique. This technology—Resin-in-Pulp (RIP)—is expected to have lower capital costs and energy consumption than CIP operations, if they are operated effectively (Australia's Mining Monthly 1991). If the use of ion exchange resins is found to be compatible with a wide range of ores, the industry may shift to these resins wherever activated carbon is now used.

The number and size of tanks used in domestic CIP and CIL facilities vary. For example, the Ridgeway facility in South Carolina uses 10 tanks measuring 52 feet in diameter and 56 feet in height; the Mercur Mine uses 14 tanks, each of which are 30 feet in diameter and 32 feet in height; the Golden Sunlight Mine uses 10 tanks, each of which are 40 feet in diameter and 45 feet in height. Retention times vary as well, ranging from 18 to 48 hours, depending on the facility, equipment used, and ore characteristics (Smolik et al. 1984; Fast 1988; Zaburunov 1989). The amount of gold ore beneficiated by tank cyanidation methods increased since the mid 1980s.

Ore preparation (including grinding, lixiviant strength, and pulp density adjustment) and the time required to leach precious metal values varies depending on the type of ore. Oxide ores are typically beneficiated by grinding to 65 mesh and leaching with 0.05 percent sodium cyanide (for a pulp density of 50 percent solids) over a 4- to 24-hour period. Sulfide ores are typically beneficiated by grinding to 325 mesh and leaching with 0.1 percent sodium cyanide for a 10- to 72-hour period (for a pulp density of 40 percent solids) (Weiss 1985). *Carbon-in-Pulp*

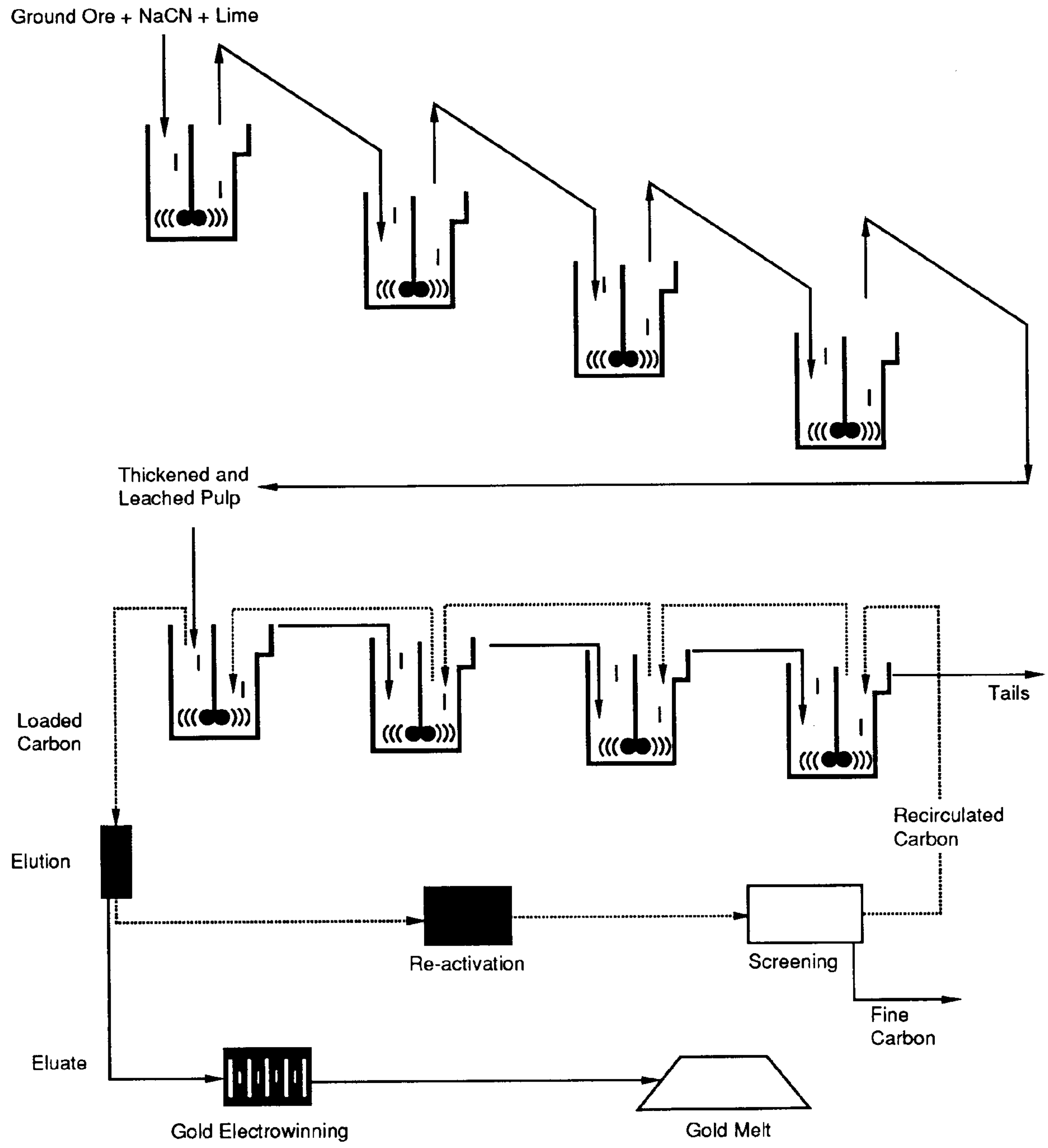


Figure 1-9. Typical Carbon-in-Pulp (CIP) Circuit

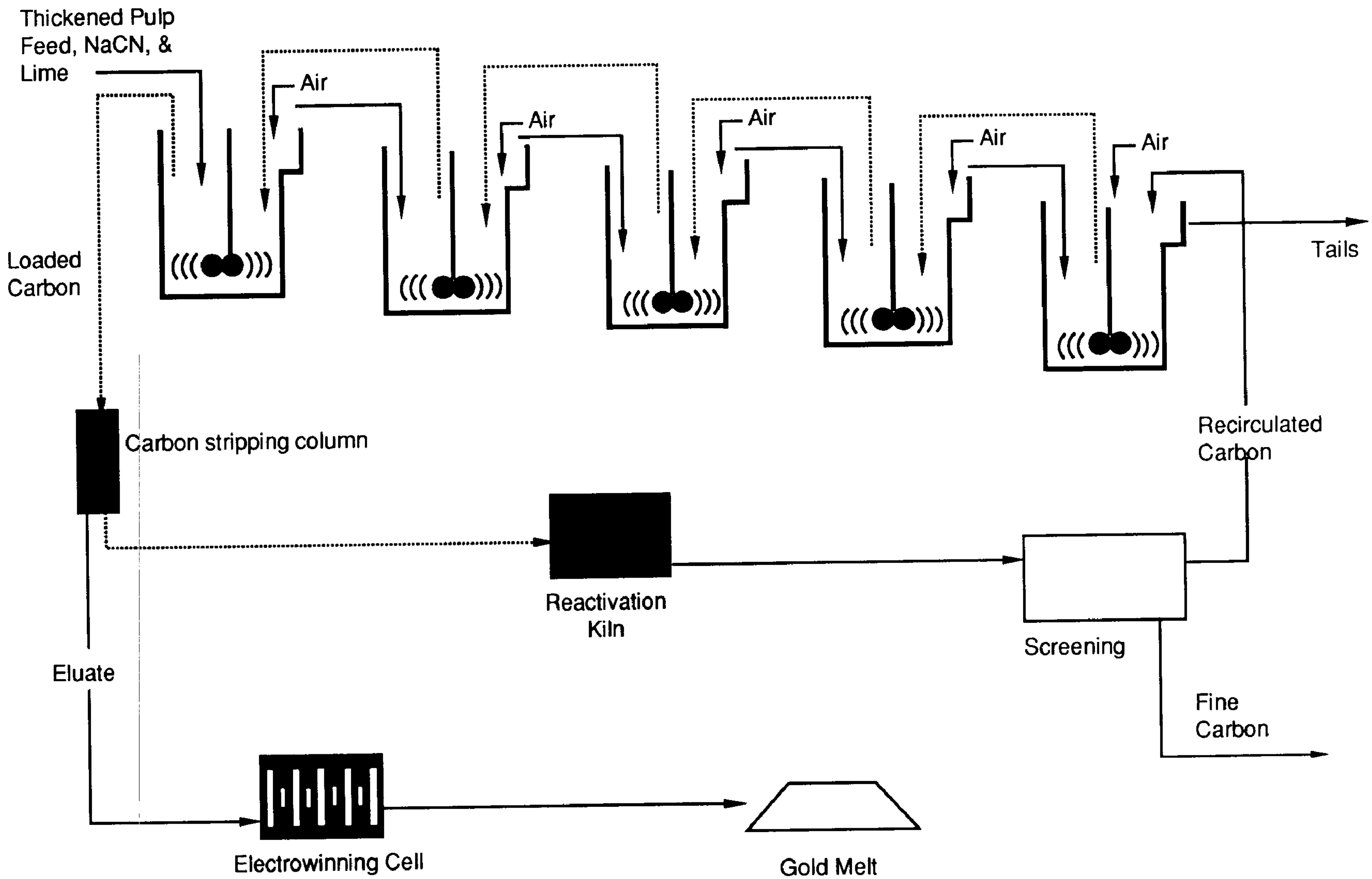
(Source: Calgon, Granular Carbon for Gold Recovery undated.)

In the CIP technique, a slurry of ore, process water, cyanide, and lime is pumped to the first series of tanks for agitation and leaching. Gold is leached from the ore in the leach tank train. The slurry containing leached ore and pregnant solution is pumped to the second series of tanks for recovery. A diagram of this technique is presented in Figure 1-9.

In the second series of CIP tanks, the slurry is introduced into a countercurrent flow with activated carbon. The slurry enters the first tank in the series containing carbon that is partially loaded with the gold-cyanide complex (see Figure 1-9) (Calgon Carbon Corporation, undated). In the suspended slurry, the activated carbon adsorbs gold material on the available exchange sites. As the carbon material becomes laden with precious metals, the carbon is pumped forward in the circuit toward the incoming solids and pregnant solution. Thus, in the last tank, the low-gold percentage solution is exposed to newly activated and relatively gold-free carbon that is capable of removing almost all of the remaining precious metals in the solution. Fully loaded carbon is removed at the feed end of the absorption tank train for elution, followed by electrowinning or zinc precipitation as described previously. (U.S. DOI, Bureau of Mines 1978, 1986; Stanford 1987).

Carbon-in-Leach

The CIL technique differs from CIP in that activated carbon is mixed with the ore pulp in a single series of agitated leach tanks. Leaching and recovery of values occur in the same series of tanks. A countercurrent flow is maintained between the ore and the leaching solution and activated carbon (see Figure 1-10


Thickened Pulp Feed, NaCN, & Lime
Air
Air
Air
Air
Air
Loaded Carbon
Tails
Carbon stripping column
Recirculated Carbon
Reactivation Kiln
Screening
Eluate
Fine Carbon
Electrowinning Cell
Gold Melt

) (Calgon Carbon Corporation, undated). In the first tanks of the series, leaching of the fresh pulp is the primary activity. In later tanks, adsorption is dominant as fresh carbon is added to the system countercurrent to the pulp. Adsorption takes place as the gold-cyanide complex mixes with the carbon. As with Carbon-in-Pulp and heap leach operations, the pregnant carbon undergoes elution to remove values. The pregnant eluate then undergoes electrowinning or zinc precipitation prior to smelting.

Tank beneficiation methods produce a waste slurry of spent ore pulp or tailings. Spent ore is pumped as a slurry to a tailings impoundment (U.S. DOI, Bureau of Mines 1986; Calgon Carbon Corporation, undated; Stanford 1987). This solution may contain cyanide, spent ore, lost gold-cyanide complex, gold in solution, and any constituents in the water used in the operation to control shale. Small amounts of gold will continue to be leached in the tailings impoundment and some gold may be recovered as this solution is recirculated back to the mill.

Barren leaching solution is either recycled directly back to the beneficiation circuit or sent to a tailings impoundment depending on the amount of solids in the solution. This solution may contain spent ore, residual cyanide solution, and minor amounts of gold.

In situ Leaching

In situ leaching, although common in the copper industry, is only an experimental procedure in the gold industry and is not used in commercial operations. It involves blasting an underground deposit in place to fracture the ore and make it permeable enough to leach. Subsequently, 20 to 25 percent of the broken ore is removed from the mine to provide "swell" space for leaching activities. In buried ore bodies, cyanide solution is then injected through a well into the fractured ore zone (see Figure 1-11). At surface ore bodies, the solution can simply be sprayed over the deposit. Recovery wells are

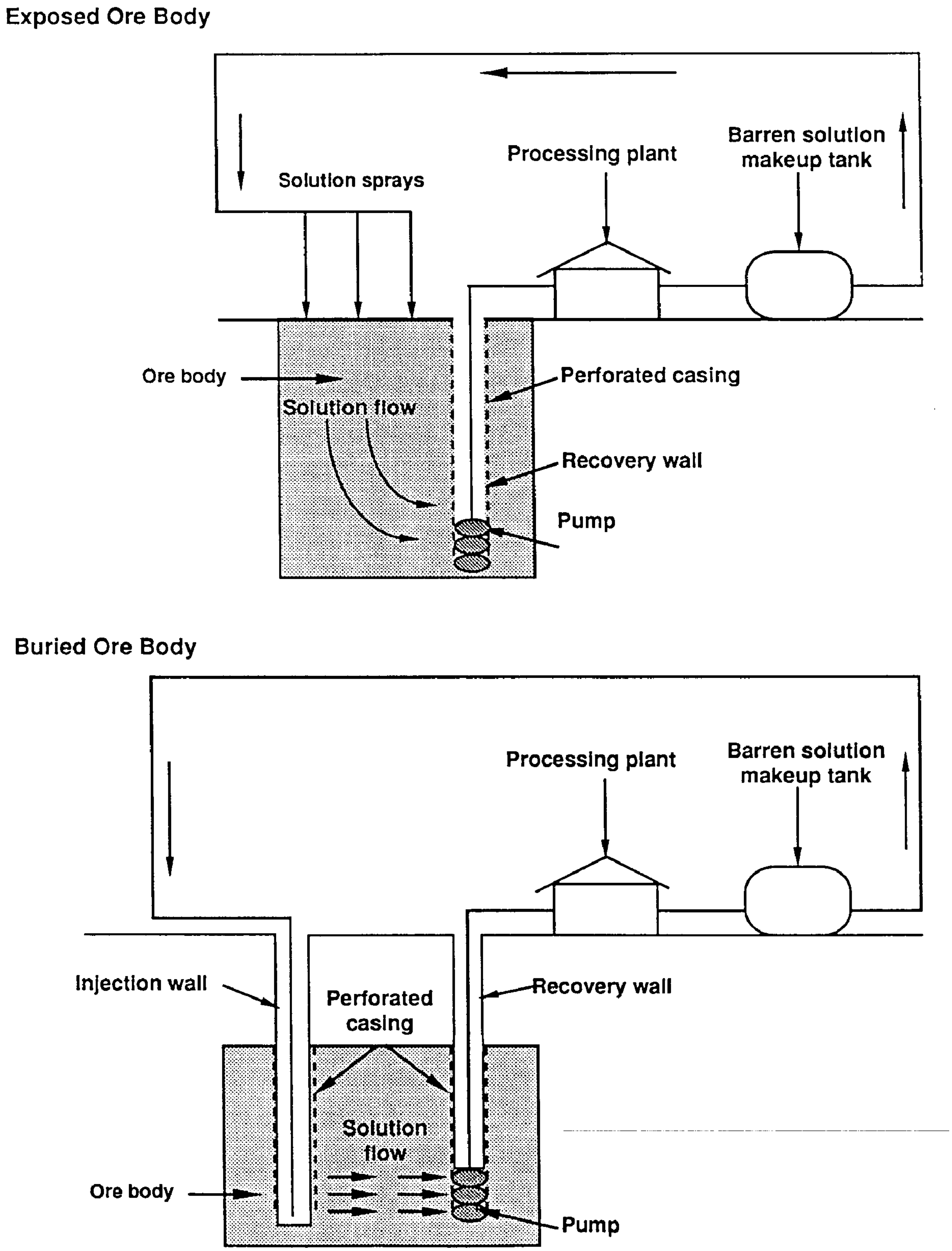


Figure 1-11. Typical In Situ Leaching Systems for Exposed and Buried Ore Bodies

(Source: U.S. DOI, Bureau of Mines 1984.)

used to collect the gold-cyanide solution after it percolates through the ore. Ground and surface water concerns, similar to those found with dump leach sites, are commonly cited for *in situ* operations. *In situ* leaching has only been tested at the Ajax Mine near Victor, Colorado (U.S. DOI, Bureau of Mines 1984).

1.5 WASTES AND OTHER MATERIALS ASSOCIATED WITH GOLD EXTRACTION AND BENEFICIATION

This section describes several of the wastes and materials that are generated and/or managed at gold extraction and beneficiation operations and the means by which they are managed. As is noted in the previous section, a variety of wastes and other materials are generated and managed by gold mining operations.

Some, such as waste rock and tailings, are generally considered to be wastes and are managed as such, typically in on-site management units. Even these materials, however, may be used for various purposes (either on- or off-site) in lieu of disposal. Some quantities of waste rock and tailings, for example, may be used as construction or foundation materials at times during a mine's life. Many other materials that are generated and/or used at mine sites may only occasionally or periodically be managed as wastes. These include mine water removed from underground workings or open pits, which usually is recirculated for on-site use (e.g., as mill/leaching makeup water) but at times can be discharged to surface waters. As another example, leaching solutions are typically regenerated and reused continuously for extended periods. On occasion, however, such as at seasonal or permanent closure, the solutions are disposed as wastes via land application or other means. Finally, some materials are not considered wastes at all until a particular time in their life cycles. These include spent ore at heap leaching operations: here, only when active leaching for precious metals recovery ends is the spent ore that comprises the heap considered a waste.

The issue of whether a particular material is a waste clearly depends on the specific circumstances surrounding its generation and management at the time. In addition, some materials that are wastes within the plain meaning of the word are not "solid wastes" as defined under RCRA and thus are not subject to regulation under RCRA. These include, for example, mine water or process wastewater that is discharged pursuant to an NPDES permit. It is emphasized that any questions as to whether a particular material is a waste at a given time should be directed to the appropriate EPA Regional office.

Facilities also store and use a variety of chemicals that are required by mine and mill operations. A list of chemicals used at gold mines, compiled from data collected by the National Institute for Occupational Safety and Health, is provided in the table below (National Institute for Occupational Safety and Health, 1990). The first subsection below describes several of the more important wastes (as defined under RCRA or otherwise) and nonwastes alike, since either can have important implications for environmental performance of a facility. The next subsection describes the major types of waste units and mine structures that are of most environmental concern during and after the active life of an operation.

Chemicals Used at Gold Mines

Acetic Acid	Diisobutyl Ketone	Methyl Acetylene-Propadiene Mixture	Silica, Sand
Acetone	Ethanol	Methyl Alcohol	Silica, Crystalline
Acetylene	Fluoride	Methyl Chloroform	Silver
Ammonia	Graphite	Mineral Oil	Silver Nitrate
Argon	Hexane	Molybdenum	Sodium Cyanide
Asbestos	Hydrogen Bromide	Nitric Acid	Sodium Hydroxide
Butyl Acetate	Hydrogen Chloride	Nitrogen	Stoddard Solvent
Calcium Carbonate	Hydrogen Peroxide	Nitrous Oxide	Sucrose
Calcium Oxide	Iron Oxide Fume	Oxalic Acid	Sulfuric Acid
Carbon Dioxide	Kerosene	Phosphoric Acid	Tin
Chlorine	Lead	Portland Cement	Vanadium Pentoxide
Coal	Lead Nitrate	Potassium Cyanide	Xylene
Copper	Litharge	Propane	2-Butanone
Diatomaceous Earth	Mercuric Chloride	Pyridine	Diesel Fuel No. 1
Dichlorodifluoromethane	Mercury		

1.5.1 Extraction and Beneficiation Wastes and Materials

The subsections below describe many of the wastes and materials generated and managed at gold sites. Notwithstanding the status of a particular waste or material, it should be noted that a number of factors that determine whether that waste or material poses any risk to human health or the environment. Perhaps the most important are the inherent nature of the material (which is generally determined by its origin and the processes by which it is generated), the manner in which the material is managed, and the environment in which it is managed and to which it could be released. As noted above, questions concerning the actual status of any particular material or waste should be directed to the appropriate EPA Region.

1.5.1.1 RCRA Defined Wastes

Waste Rock

According to the 1985 *Report to Congress: Wastes From the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale*, the greatest quantity of waste generated as a result of the mining and beneficiation of gold ore is in the form of overburden and mine development rock. Industry refers to these materials as waste rock. Generally, these materials are deposited in waste rock piles or dumps. It was estimated that the gold mining industry generated 25 million metric tons of overburden and mine development rock in 1980 and 39 million metric tons in 1982 (U.S. EPA 1985). Surface mining operations generate more waste per unit of crude ore extracted than underground operations. At surface mines, 71 percent of all material handled is discarded as waste. At underground mines, 20 percent of all material handled is discarded. Using equivalent units, the ratio of material handled to marketable gold produced at lode operations is 682,000:1, the highest among metal ores (U.S. DOI, Bureau of Mines 1991a).

The quantity and composition of waste rock generated at mines vary greatly by site. This material can contain either oxides or sulfides, depending on the composition of the ore body. Constituents found in gold ores may include mercury, arsenic, bismuth, antimony, and thallium. These may occur as oxides, carbonates, and sulfides with varying degrees of solubility. Sulfur-bearing minerals, such as pyrite and pyrrhotite, can oxidize to form sulfuric acid (U.S. DOI, Bureau of Mines 1984). Factors that influence acid generation by sulfide wastes include (1) the amount and frequency of precipitation; (2) the design of the disposal unit; and (3) the acid generation and neutralization potential of the rock.

Spent Ore from Tank Leaching (Tailings)

Tank leaching, both CIP and CIL circuits, generate spent ore by leaching the gold values from finely ground ore. The spent ore exits the leach circuit as a slurry composed of gangue and process water bearing cyanide and cyanide-metal complexes. The characteristics of this waste vary greatly, depending on the ore, cyanide concentration, and the source of the water (fresh or recycled). The characteristics of the gangue are dependent on the ore source. The tailings may be treated to neutralize cyanide prior to disposal. The slurry is typically disposed of in a tailings impoundment with some of the free liquid component being recirculated to the tank leach as make-up water. In some cases, tailings may be used to backfill underground workings or used in on- or off-site construction.

Spent Ore From Heap Leaching

Heap or valley fill leaching generates spent ore when leaching operations cease, usually after the economically recoverable gold is removed from the ore. Spent ore may contain residual cyanide prior to initiation of detoxification procedures; some residual cyanide may remain complexed with other constituents. Spent ore would contain any trace metals present in the ore body. The spent ore in most heaps is left in place for detoxification and disposal. Ore leached on on-off heap leach pads is removed after leaching and detoxification and disposed of at an alternative site, such as waste rock or spent ore disposal sites.

Pads and liners used in heap leaching operations are considered to be wastes when intended for disposal, typically at closure of the facility. Depending on the types of liners used in any associated ponds or collection ditches, some cyanide, cyanide-metal complexes, and gold-cyanide solution may remain. Ponds and collection ditches may be reclaimed in place by backfilling with fill material; the pond or ditch liner material may be disposed of in place or removed for detoxification and disposal elsewhere.

Cyanide Solution

During operation, most of the barren cyanide solution is recycled to leaching activities. However, the build-up of metal impurities may interfere with the dissolution and precipitation of gold and, therefore, require a portion of the solution volume to be bled off and disposed of (U.S. EPA, Office of Water 1982). Also, barren cyanide solution from both tank and heap leaching must be disposed of following mine closure (whether seasonal, extended, or permanent closure). In either case, solutions will contain free cyanide and metallo-cyanide complexes of copper, iron, nickel, and zinc, as well as other impurities, such as arsenic and antimony, that are mobilized during leaching. Solutions may be evaporated from ponds, discharged to tailings impoundments, or land-applied (after treatment to detoxify the cyanide).

Zinc Precipitation Wastes

The wastes from zinc precipitation include a filter cake generated from initial filtering of the pregnant solution prior to the addition of zinc, and spent leaching solution that is not returned to the leaching process. The filter cake consists primarily of fine gangue material and may contain gold-cyanide complex, zinc, free cyanide, and lime. The filter may be washed with water, which is disposed of as part of the waste. The waste is typically sent to tailings impoundments or piles.

Wastes From Carbon Regeneration

Carbon used in adsorption/desorption can be reactivated numerous times. The regeneration technique varies with mining operations, but generally involves an acid wash before or after extraction of the gold-cyanide complex, followed by reactivation in a kiln. Carbon particles not of optimum size are either lost to the tailings slurry, or to the greatest extent practicable, captured after reactivation. Carbon lost to the circuit is replaced with virgin, optimum-size carbon. Wastes from the reactivation circuits may include carbon fines and the acid wash solution. The carbon may contain small amounts of residual base metals and cyanide. The acid wash residues may contain metals, cyanide, and the acid (typically hydrochloric or nitric); according to Newmont Gold Company, the acid is usually neutralized in a totally enclosed system prior to release. Up to 10 percent of the carbon may be lost in any given carbon recovery/reactivation circuit from abrasion, ashing, or incidental losses. Most operations capture less-than-optimum-size carbon particles for recovery of additional gold values (either on-site or after being sent off-site). Recovery may involve either incineration and subsequent recovery of the gold that could not be desorbed chemically during the normal course of operations, or subjecting the material to an extended period of concentrated cyanide leach. Any liquids used to wash or transport carbon material are generally recirculated.

Amalgamation Wastes

The slurry waste generated by amalgamation is composed of the mercury-bearing solution and gangue. The characteristics of waste water and gangue from amalgamation vary greatly depending on the ore. This waste may be pumped to a tailings pond. Modern placer operations in California have recovered mercury from the sediments as a byproduct of historic gold mining. The source of the mercury is waste from historical amalgamation operations.

1.5.1.2 Materials

Mine Water

Because mine water discharged to the environment can be a source of contamination, it is addressed in this section although it is not always a RCRA-defined waste. Mine water consists of water that collects in mine workings, both surface and underground, as a result of inflow from rain or surface water, and ground water seepage. As discussed previously, mine water may be used and recycled to the beneficiation circuit, pumped to tailings impoundments for storage prior to recycling or for disposal, or discharged to surface water under an NPDES permit.

During the life of the mine, if necessary, water is pumped to keep the mine dry and allow access to the ore body. This water may be pumped from sumps within the mine pit or from interceptor wells. Interceptor wells are used to withdraw ground water and create a cone of depression in the water table around the mine, thus dewatering the mine. Surface water contributions to the volume of mine water are generally controlled using engineering techniques to prevent water from flowing into the mine, typically by diverting it around pits or underground openings.

The quantity and chemical composition of mine water generated at mines vary by site. The chemistry of mine water is dependent on the geochemistry of the ore body and surrounding area. After the mine is closed and pumping stops, the potential exists for mines to fill with water. Water exposed to sulfur-bearing minerals in an oxidizing environment, such as open pits or underground workings, may become acidified. In contrast, according to Homestake Mining Company, flooding and subaqueous deposition of tailings has been used in some unique situations to prevent acidification in mines.

1.5.2 Waste and Materials Management

Wastes and materials that are generated as a result of extraction and beneficiation of gold ore are managed (treated, stored, or disposed of) in discrete units. For the purposes of this report, waste units are divided into three groups: (1) waste rock piles or dumps; (2) tailings ponds; and (3) spent ore piles once the leaching operation ceases in the case of heap leach operations. These units may be exposed to the environment, presenting the potential for contaminant transport. In addition, mine structures such as pits and underground workings are described in this section as they may expose constituents to the environment and increase the potential for transport.

1.5.2.1 RCRA Units

Waste Rock Piles

Overburden and mine development rock removed from the mine are stored or disposed of in on-site piles. These piles may also be referred to as mine rock dumps or waste rock dumps. Usually constructed without liners, these waste dumps are generally unsaturated. Such dumps can generate acid drainage if sulfide minerals, oxygen, and moisture are present in sufficient concentrations, without adequate neutralization potential or other controls in the dump itself. As appropriate, topsoil may be segregated from the overburden and mine development rock and stored for later use in reclamation and revegetation.

Tailings Impoundments

The disposal of spent ore from tank leaching operations (tailings) requires a permanent site with adequate capacity for the life of the mine. The method of tailings disposal is largely controlled by the water content of the tailings. Generally, three types of tailings may be identified based on their water content: wet (greater than 40 percent of the total weight is water), thickened (approximately 40 percent water), and dry (less than 30 percent water). Tailings impoundments are used to dispose of the following types of waste:

- Tailings,
- Mine water,
- Small amounts of activated carbon,
- Zinc precipitation wastes,
- Barren cyanide solution and cyanide metal complexes, and
- Liners and wastes from decommissioned solution ponds, tanks, and collection ditches.

Two general classifications of impounding structures may be used to describe a tailings impoundment: retention dams and raised embankments. The choice of impounding structure is influenced by the characteristics of the mill tailings, and area geology and topography. In a few cases, cyanidation tailings impoundments have been lined with synthetic or clay liners to inhibit seepage of tailings water.

The size of tailings impoundments varies between operations. For example, the Golden Sunlight Mine near Whitehall, Montana is planning an expansion; when completed, the total surface area of the facility's tailings impoundments will be 450 acres with a depth of 150 feet. The impoundment at the Ridgeway Mine in South Carolina currently measures 210 acres, but was to be expanded to 270 acres when a new pit comes into production. The Pegasus Gold Corporation in Washington, proposed to use staged construction to build their tailings impoundment embankment. Design capacity was 49 million tons of tailings (Montana Tunnels Mining, Inc. 1990; Zaburunov 1989).

Spent Ore Piles

Spent ore in heaps that have previously been leached using cyanide (or other lixiviant), and the associated pads, may contain small amounts of residual cyanide solution and gold-cyanide complexes. Usually the heap remains in place as a form of spent ore disposal; treatment to neutralize the cyanide and/or other contaminants, as well as puncturing the liner to allow percolation, may be conducted prior to abandonment. The spent ore typically contains unleached metals and other minerals characteristic of the ore body that may present a potential for contaminant transport. During the design of the heap, it is important to consider that heaps are not only leaching units during active operations, but also become waste units as the heap is depleted of values.

Spent ore from on-off pads is detoxified, removed, and disposed of in waste rock dumps or spent ore disposal areas. As discussed in the Ore Characterization Section of this report, the mineralogy varies widely with the source of the gold ore (U.S. DOI, Bureau of Mines 1984). Spent leach piles are reported to vary from 2,000 to 1.5 million short tons in size (Versar, Inc. 1985). The Mesquite Mine in Imperial County, California, uses heaps 75 feet high (20 foot lifts) and covering 92 acres (Silva 1988).

1.5.2.2 Non-RCRA Units

Mine Pits and Underground Workings

Pits and underground workings may be allowed to fill with water when a mine closes or stops operation, since there is no longer a need for dewatering. This accumulated water may acidify through contact with sulfide minerals in an oxidizing environment resulting in acid generation. The acid, in turn, may mobilize metals in the remaining rock. In some cases pits and underground workings are backfilled with waste rock or tailings. The potential for contaminant release is dependent on site-specific factors.

Abandoned underground mines and mine shafts may be unprotected, and the mine may, with time, subside, though this is mostly a problem with historical mines. Deficiencies in mine shaft protection may be caused by the use of unsuitable materials, such as inadequate shaft cappings, or by unexpected occurrences that break capping seals, such as water surges in flooded mines (U.S. DOI, Bureau of Mines 1983a).

1.6 ENVIRONMENTAL EFFECTS

Mine pits and underground workings, overburden piles, waste rock dumps, tailings impoundments, and spent leach piles in the gold industry are potential sources of environmental contamination. While all are not waste management units, these are areas in which toxic contaminants are commonly found and have the potential to escape into the environment. Toxicants associated with these areas may include cyanide, cyanide-metal complexes, heavy metals, and acid rock drainage. These toxicants may degrade ground water, surface water, soil, and air quality during mine operation and after mine closure. A discussion of the potential environmental effects associated with gold mining is presented in the following sections. Specific examples from industry are included in this section, as appropriate.

This section on environmental effects does not purport to be a comprehensive examination of environmental effects that can occur or that actually occur at mining operations. Rather, it is a brief overview of some of the potential problems that can occur under certain conditions. EPA is aware that many of the potential problems can be, and generally are, substantially mitigated or prevented by proper engineering practices, environmental controls, and regulatory requirements.

1.6.1 Ground Water/Surface Water

The primary concerns for ground and surface water at mine sites are chemical and physical contamination associated with mine operation. Acid formed by the oxidation of sulfide minerals may be a source of long-term problems at facilities that extract and beneficiate sulfide ores. In addition to wastes, reagents, such as sodium cyanide, used during beneficiation may also be released to ground and/or surface water. Mine rock dumps, disturbed areas, and haul roads may contribute sediment and increase the total solids load to surface water bodies. Potential environmental issues related to ground water are discussed in more detail below.

1.6.1.1 Acid Generation

Acid rock drainage refers to drainage that occurs as a result of the natural oxidation of sulfide minerals contained in rock that is exposed to air and water. This phenomenon is often referred to as acid mine drainage (AMD); however, it is not necessarily confined to mining activities and can occur wherever sulfide-bearing rock is exposed to air and water. Not all operations that expose sulfide-bearing rock will generate acid drainage. The potential for acid drainage to occur depends on the amount and frequency of precipitation, the acid generation and neutralization potential of the rock, presence of oxygen, and the design of the disposal unit (e.g., encapsulation).

Water percolating through mine workings or piles such as tailings or waste rock may leach sulfides from the ore and surrounding rock and result in the formation of acid drainage. This acid solution may be discharged to ground or surface water, depending on the hydrology of the site. The acid generation potential, as well as the potential for release of other constituents, is increased after the rock is exposed to the atmosphere (i.e., an oxidizing environment). The rate of acid generation is also influenced by the presence or absence of bacteria.

Bacteria, especially *Thiobacillus ferrooxidans,* are able to oxidize sulfur-bearing minerals. The effect of bacteria is pH-dependent; in some cases, lowering of pH over time produces a favorable environment for specific bacteria, leading to accelerated acid generation, once the pH reaches the appropriate level.

In rock dumps, overburden piles, and other mine materials piles that are typically unsaturated, acid drainage may start to form immediately. The acid generation potential, as well as the potential for release of other constituents, is increased in these units compared to the in-place ore body because the rock is finely ground or crushed, thus presenting greater particle surface area, and is in an oxidizing environment. Changes in pH directly affect the availability and transport of metals and other constituents. In addition, mine dewatering/flooding may result in similar impacts, as discussed in the following section.

Milled tailings are susceptible to leaching because of the increased surface area exposure of minerals not extracted during milling. Surface water discharges and seeps from tailings impoundments may contain elevated concentrations of metals leached from the tailings. Acid drainage from tailings impoundments may contribute to the leaching and mobility of metals.

1.6.1.2 Mine Dewatering

Surface and underground mines may be dewatered to allow extraction of ore. Dewatering can be accomplished in two ways: (1) pumping from ground water interceptor wells to lower the water table and (2) pumping directly from the mine workings. At the end of a mine's active life, pumping typically is stopped and the pit or underground workings are allowed to fill with water. Over time, depending on final hydrologic equilibrium, filling may lead to uncontrolled releases of mine water. The mine water may be acidic and/or contaminated with metals, as well as suspended and dissolved solids.

1.6.1.3 Release of Cyanide Solution From Active Heap Leach Units

Release of cyanide solutions from active leach piles or leachate collection ponds may occur during snowmelt, heavy storms, or failures in the pile or pond liners and associated solution transfer equipment. Although not waste-management related, at some operations, monitoring systems for cyanide releases may be installed to detect leaks below the pond and in receiving waters. Monitoring systems are required by some States; see the discussion in the Current Regulatory and Statutory Framework Section.

Release incidents were identified by Versar (Versar, Inc. 1985), with most releases being associated with leachate holding ponds. Doyle (1990) also reported five spill events that occurred during heap leaching activities in Idaho. Releases of cyanide were caused by heavy snowmelt and ice damage. Typically, the facility failed to design and monitor a leak detection system and neutralize cyanide solution prior to winter closure. Although most of these releases were to surface water, cyanide could also be released to ground water.

At the Summitville Site in Colorado failures in the liner have led to contamination of both surface and ground water. Discharge from French drains below the heap is contaminated with cyanide. Release of process water into Wightman Fork of the Alamosa River lead to fish kills in 1986.

At the Kendall Venture mine site in Lewiston, Montana, the ground water beneath the site has become contaminated with nitrate and cyanide in recent years. Nitrate concentrations in one well have risen from 0.016 milligrams per liter (mg/l) in 1988 to 13.6 mg/l in 1989, exceeding the State Drinking Water Quality Standard of 10 mg/l. Total cyanide concentrations inside the permit boundary of the facility have increased from 0.16 mg/l in 1988 to 0.26 mg/l in 1989. The State's "informal" water quality limit of 0.22 mg/l of free cyanide is set for waters outside the permit boundary. The permit allows the mine facility to maintain higher levels for the areas addressed by the permit.

In October 1990, following heavy rains, 10 to 12 million gallons of cyanide solution (100 ppm cyanide) and several tons of sediment spilled into Little Fork Creek and the Lynches River in South Carolina from the Brewer Gold Mine. During the same storm, debris blocked a collection channel and caused a 420,000-gallon spill containing 170 ppm cyanide. The spill resulted in the discoloration of Little Fork Creek and a fishkill for 49 miles down Lynches River (Doyle 1990; South Carolina Department of Health and Environmental Control 1990).

In addition to surface and ground water contamination, both cyanide solution collection ponds and water in the collection ditches at heap leach operations may contain cyanide and, therefore, may be potential sources of contamination for birds and other animals that come into contact with the pond. In response to this, some mine operations are opting to construct tanks for pregnant solutions and otherwise trying to cover existing ponds with fences, nets, or screens to control access to these water sources. Other tactics used to repel wildlife include recorded sounds of predator birds, air cannons, stuffed owls, scarecrows, and firing of hazing shells (Zaburunov 1989). EPA and industry manufacturers of sodium cyanide have entered into a voluntary testing Consent Order to address concerns identified by the U.S. Department of the Interior (DOI) Fish and Wildlife Service relating to wildlife exposure to cyanide.

1.6.1.4 Release From Heap Leach Piles During and After Closure (Reclamation)

When heap leach operations are concluded, a variety of different constituents remains in the wastes. These include cyanide not removed during rinsing or neutralization, as well as heavy metals, and sulfides. After the operation has been closed or reclaimed, runoff from the spent ore may occur without proper design and construction considerations. This runoff may contain constituents associated with the ore, such as heavy metals, and total suspended solids. Depending on the method and completeness of detoxification, spent ore may also continue to have a high pH. Reclaimed piles may have passive controls to control run-on and runoff; the design capacity of these controls may be based on the 10-, 25-, or 100-year 24-hour maximum storm event or the probable maximum precipitation event, depending on the component. The specific requirements are usually determined by the State.

If sulfide ores are present, they may generate acidic leachate which may mobilize the metals that are present in the ore. The constituents associated with the leachate (metals and arsenic) can cause degradation of ground and surface water quality.

1.6.2 Soil

Three types of environmental effects are commonly associated with soils: erosion, sedimentation, and contamination. Erosion and sedimentation may be caused by land disturbances and removal of vegetation related to mining activities (situations that are not unique to mining activities). Under these conditions, precipitation and snowmelt may lead to soil erosion. Soil contamination may result from solution spills associated with equipment (hydraulic oil), releases of leach solution because liner or other equipment failure, deposition of contaminated runoff from waste rock piles, or other circumstances. Included in this section is a review of methods to detoxify cyanide, because spent solutions are often land-applied as a disposal method.

1.6.2.1 Land Application of Spent Cyanide Solution

Spent cyanide solution is generated as a waste during heap leach operations and closure. Prior to land application, these solutions may also be neutralized using calcium hypochlorite or ozone, or other methods (Porath 1981). Cyanide may be degraded or attenuated in soils by volatilization, chelation, precipitation, adsorption, biodegradation, and oxidation to cyanate. Long-term persistence of cyanide residues in mining waste are not completely understood (University of California at Berkeley 1988).

1.6.2.2 Detoxification of Cyanide

The probable fate and transport of cyanide in mine wastes were reported as part of the Mining Waste Regulatory Determination (1986). The rinse solution used to remove residual cyanide and associated metal complexes from heaps usually consists of fresh or recirculated mine or process water. Rinsing continues until the effluent contains a predetermined cyanide concentration. Today, current technology and environmental concerns have led to the development of technologies that attempt to render cyanide benign in the environment. Many methods exist for complexing or decomposing cyanide prior to disposal. These are listed below (University of California at Berkeley 1988):

- Lagooning or natural degradation through photodecomposition, acidification by CO_2 and subsequent volatilization, oxidation by oxygen, dilution, adsorption on solids, biological action, precipitation with metals, and leakage into underlying porous sediments.

- Oxidation by various oxidants.

    - Chlorine gas

    - Sodium and calcium hypochlorites

    - Electro-oxidation and electrochlorination

- Ozone
- Hydrogen peroxide
- Sulfur dioxide and air.

In all cases, cyanide is oxidized initially to the cyanate, CNO^-. In some cases the cyanate ion is oxidized further to NH_4+ and HCO_3-, and finally the ammonium ion may be oxidized to nitrogen gas.

- Acidification, with volatilization and subsequent adsorption of HCN for reuse.
- Adsorption of cyanide complexes on ion exchange resins or activated carbon.
- Ion and precipitation flotation through cyanide complexation with base metals and recovery with special collectors.
- Conversion of cyanide to less toxic thiocyanate (CNS^-) or ferrocyanide ($(Fe(CN)_6)^{4-}$.
- Removal of ferrocyanide by oxidation or precipitation with heavy metals.
- Biological oxidation.

Each treatment method may generate a different waste with the chemical compounds used in cyanide removal as constituents. EPA is currently preparing a separate report on cyanide detoxification. Some of these (e.g., chlorine, ozone, hydrogen peroxide) are toxic to bacteria and other life forms but are unlikely to persist or can be cleaned up easily. Others (e.g., chloramine or chlorinated organic compounds) may persist for long periods in the natural environment.

Detoxification of cyanide using hydrogen peroxide is applicable to spent heaps, tailings, and solution ponds and tanks. The cyanide-bearing solution is sent to a series of hydrogen peroxide reaction tanks. (Ahsan et al. 1989.) Hydrogen peroxide and lime are added to the solution forming precipitate of metal hydroxides and oxidizing free and weakly complexed cyanide into cyanate (OCN-). Additional steps precipitate copper ferrocyanide, a reddish-brown solid that is stable at a pH of less than 9. Precipitates are separated from the solution and discharged to the tailings impoundment. The solution is then recycled until the desired cyanide concentration is attained in the effluent.

INCO has also developed a technique for detoxification of mine waste streams containing cyanide -- such as CIP and CIL pulps, barren solution, pond waters, and heap leach rinse solutions -- by removing cyanide and base metal complexes. The INCO process uses SO_2 and air, which is dispersed in the effluent using a well-agitated vessel. Acid produced in the oxidation reaction is neutralized with lime at a controlled pH of between 8 and 10. The reaction requires soluble copper, which can be provided in the form of copper sulfate (Devuyst et al. 1990).

States have adopted specific standards for land application of spent cyanide solutions. For example, South Dakota has set the level for land application of solutions with cyanide at 0.2 mg/l, with additional requirements for concentrations of other heavy metals, sulfides, and other constituents, in conjunction with additional application and monitoring requirements.

EPA is unaware of detailed, long-term field evaluations of the efficiency of any of the cyanide detoxification methods.

1.6.3 Air

1.6.3.1 Fugitive Dust

The primary sources of air contamination at mine sites are fugitive dust from mine pits and tailings impoundments. During the active life of the mine, water or chemicals may be applied to these impoundments to control dust and prevent entrainment. After mine closure, revegetation or other stabilizing methods may be used to control dust. Air provides exposure routes for constituents (inhalation, deposition, and subsequent soil or surface water contamination, etc.). The potential contaminants are heavy metals and other toxics.

1.6.4 Damage Cases

Environmental damages resulting from mining gold and associated minerals have been documented. Under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (Superfund) and the CWA, EPA has documented contamination to ground water, surface water, air, and soil media.

1.6.4.1 National Priorities List

EPA has reviewed mining sites on the National Priorities List (NPL). Five sites on the Superfund NPL have problems related to gold extraction and beneficiation: Carson River, Nevada; Clear Creek/Central City, Colorado; Cimarron Mining Corporation, New Mexico; Silver Mountain Mine, Washington; and Whitewood Creek, South Dakota. Appendix 1-B provides a general site description and a summary of the environmental effects associated with each site.

1.6.4.2 304(l) Sites

Section 304(l) of the Water Quality Act of 1987 requires States to identify water bodies not meeting applicable water quality criteria, to identify point-source dischargers to these water bodies, and to develop and require implementation of individual control strategies (ICSs) for those point-source dischargers that contribute significantly to exceedance to the water quality criteria. Sunnyside Gold (Mayflower Mill) and Clear Creek/Central City are sites identified under 304(l) as point-source dischargers of contaminants related to gold mining activities. A summary of each site is provided in Appendix 1-C. Note that one of these sites, Clear Creek/Central City, is on the NPL and is discussed in Appendix 1-B as well.

1.7 CURRENT REGULATORY AND STATUTORY FRAMEWORK

Gold mining activities are regulated through a complex set of Federal and State regulations. Statutes administered by EPA, such as the CWA (33 USC §1251 et seq.) and the Clean Air Act (CAA) (42 USC §7401 et seq.), apply to mining sites regardless of where they are located. Operations on Federal lands are subject to additional regulation by the Federal agency or agencies having jurisdiction over the lands, such as the Bureau of Land Management (BLM), the Forest Service (FS), the Fish and Wildlife Service (FWS), and the National Park Service (NPS). In addition, the Army Corps of Engineers has promulgated rules for construction and mining activities that have a potential impact on wetlands and navigable waters. Finally, operations must comply with a variety of State and local requirements, some of which may be more stringent than Federal requirements.

Federal air quality regulations do not specifically address gold mining, but they do regulate sources of certain types of air pollution. Federal water quality regulations, on the other hand, include effluent discharge standards for specific types of gold operations. Federal land management agencies have regulations that, in some cases, target particular types of extraction or beneficiation methods (e.g., placer mining turbidity issues). The BLM has a policy for management of mining operations using cyanide and other leaching techniques. State regulations similarly address operation types (e.g., cyanide heap leach operations), but less frequently target specific minerals.

This section summarizes the existing Federal regulations that may apply to gold mining operations. It also provides an overview of the operational permitting, water quality, air quality, waste management, reclamation, and wetlands protection regulations in two gold-producing States (Nevada and South Carolina). The regulatory requirements for heap leach operations in 15 gold-producing States are also summarized and presented in Table 1-6

Table 1-6. Heap Leach Regulatory Requirements for the 15 Gold-Producing States

State	Heap Leach Operations	Regulated	Effluent Standard[a]	Heap Liner	Residual Cyanide Destruction
Alaska	Yes	Yes[b]	Zero Discharge	Yes[c]	Yes[c]
Arizona	Yes	Yes	Zero	Yes	No
California	Yes	Yes	Zero	Yes	Yes
Colorado	Yes	Yes	Zero	Yes[c]	Yes[c]
Idaho	Yes	Yes	Zero	Yes	Yes
Michigan	No	Yes[d]	Zero	No	No
Montana	Yes	Yes[e]	Zero	Yes[b]	Yes
Nevada	Yes	Yes	Zero	Yes	Yes[b]
New Mexico	Yes	Yes	Zero	Yes[b]	Yes
North Carolina	No	Yes[d]	Zero	No	No
Oregon	Yes	Yes	Zero	Yes	Yes
South Carolina	Yes	Yes	Zero	Yes	Yes[2]
South Dakota	Yes	Yes	Zero	Yes	Yes
Utah	Yes	Yes[f]	Zero	Yes	Yes
Washington	No	Yes[d]	Zero	Yes	No

[a]All State discharge standards must meet Federal CWA requirement for zero discharge of process waste water from cyanidation operations (40 CFR, Part 440, Subpart J, undated). All States have a 0.22 mg/l ground water concentration limit for cyanide.
[b]Requirement applied on a site-by-site basis.
[c]Regulated through solid waste regulations.
[d]State does not have regulations specific to cyanide operations because it does not have such operations. If an application to conduct a cyanide operation were received, the State would regulate it under general mining regulations with specific requirements determined on a site-by-site basis.
[e]1989 State regulations no longer exempt cyanide operations under 5 acres in size.
[f]State heap leach regulations are being developed.

(Source: Compiled from State regulations.)

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1.7.1 Environmental Protection Agency Regulations

1.7.1.1 Resource Conservation and Recovery Act

The EPA implements the Resource Conservation and Recovery Act (RCRA) to protect human health and the environment from problems associated with solid and hazardous wastes. Mining wastes are included in the Act's definition of solid waste. In 1980, RCRA was amended to include what is known as the Bevill Amendment (§3001(b)(3)(A)). The Bevill Amendment provided a conditional exclusion from RCRA Subtitle C hazardous waste requirements for wastes from the extraction, beneficiation, and processing of ores and minerals.

The exemption was conditioned upon EPA's preparation of a report to Congress on the wastes and a subsequent regulatory determination as to whether regulation under Subtitle C was warranted. EPA met its statutory obligation with regard to extraction and beneficiation wastes with the 1985 *Report to Congress: Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos,*

Overburden from Uranium Mining, and Oil Shale. In the subsequent regulatory determination (51 FR 24496; July 3, 1986), EPA indicated that extraction and beneficiation wastes (including gold mining and milling wastes) should not be regulated as hazardous but should be regulated under a Subtitle D program specific to mining waste.

1.7.1.2 Clean Water Act

Under section 402 of the CWA (33 USC §1342), all point-source discharges to waters of the United States must be permitted under the NPDES with the exception of some storm water discharges covered by the 1987 amendments to the CWA. A point source is defined as any discrete conveyance, natural or man-made, including pipes, ditches, and channels. NPDES permits are issued by EPA or delegated States.

Effluent limits imposed on an NPDES permittee are either technology-based or water-quality-based. The national technology-based effluent guideline limitations have been established for discharges from most active gold mines under the Ore Mining and Dressing Point-Source Category 40 CFR Part 44 (40 CFR, Part 440, Subpart J, undated). These regulations address point source discharges from all types of gold extraction techniques, including open-pit, underground, froth-flotation, heap, *in situ*, and tank cyanide leaching. Discharges from regulated operations must meet best available technology/best practicable technology (BAT/BPT) standards for cadmium, copper, lead, mercury, zinc, total suspended solids (TSS), and pH. The specific effluent standards for these contaminants are summarized in Tables 1-7a and 1-7b

Table 1-7a. BPT[1] and BAT[2] Standards for the Ore Mining and Dressing Point-Source Category: Copper, Lead, Zinc, Gold, Silver, and Molybdenum Ore Subcategory Concentration of Pollutants Discharged in Mine Drainage (milligrams per liter)

Pollutant	BPT Maximum for 1 Day	BPT Average of Daily Values for 30 Consecutive Days	BAT Maximum for 1 Day	BAT Average of Daily Values for 30 Consecutive Days
Cadmium	N/A	N/A	0.10	0.05
Copper	0.30	0.15	0.30	0.15
Lead	0.6	0.3	0.6	0.3
Mercury	0.002	0.001	0.002	0.001
Zinc	1.5	0.75	1.5	0.75
Total Suspended Solids	30	20	N/A	N/A
pH	6.0 - 9.0	6.0 - 9.0	N/A	N/A

1 BPT - Best Practicable Technology
2 BAT - Best Available Technology

Table 1-7b. BPT and BAT Standards for the Ore Mining and Dressing Point Source Category: Copper, Lead, Zinc, Gold, Silver and Molybdenum Ore Subcategory Concentration of Pollutants Discharged From Mills That Use the Froth-Flotation Process Alone or in Conjunction With Other Processes for Beneficiation (milligrams per liter)

Pollutant	BPT Maximum for 1 Day	BPT Average of Daily Values for 30 Consecutive Days	BAT Maximum for 1 Day	BAT Average of Daily Values for 30 Consecutive Days
Cadmium	0.10	0.05	0.10	0.05
Copper	0.30	0.15	0.30	0.15
Lead	0.6	0.3	0.6	0.3
Mercury	0.002	0.001	0.002	0.001
Zinc	1.0	0.5	1.0	0.5
Total Suspended Solids	30	20	N/A	N/A
pH	6.0 - 9.0	6.0 - 9.0	N/A	N/A

(Source: 40 CFR Part 440 Subpart J.)

. States with heap leach operations typically impose a zero-discharge requirement for process waste water from cyanide leaching operations. Permit writers can establish additional technology-based limitations at a specific mine based on best professional judgment (BPJ).

The permit writer must ensure that the NPDES permit will protect the water quality of the receiving water. Table 1-8 identifies the Federal water quality criteria established by EPA under the CWA, and the current drinking water standards, Maximum Contaminant Level (MCL), established by EPA under the Safe Drinking Water Act (SDWA). The CWA also requires each state to develop water quality standards to protect the designated uses of receiving waters. NPDES permit writers must also determine whether technology-based effluent limitations are adequate to ensure that applicable water quality standards are met. Where technology-based limits are not sufficiently stringent, water-quality-based effluent limitations must be developed. As a result, an NPDES permit may include technology-based effluent limitations for some pollutants and water-quality-based effluent limitations for other pollutants.

Table 1-8. Federal Water Quality Criteria and Drinking Water MCL [a] (mg/l)

Constituent	Fresh Acute[b]	Fresh Chronic[b]	Marine Acute[b]	Marine Chronic[b]	Maximum Contaminant Level (MCL)
Antimony	9,000	1,600	(--)	(--)	0.01 or 0.005 (option)[c]
Arsenic	190	360	36	69	0.05
Cyanide	22	5.2	1.0	1.0	0.2
Mercury	2.4	0.012	2.1	0.025	0.002
Thallium	1,400	40	2,130	(--)	0.002 or 0.001 (option)[c]

[a]There are no standards for the other metals and minerals (e.g., bismuth, tellurium, pyrite, and pyrrhotite) discussed in the section on environmental effects.

[b]Standards are relative to water hardness. Standards shown are for hardness 100.

[c](option) Where options are presented, the final limit will depend upon the selection of a Practical Quantitation Limit (PQL), the limit of detection at which analysis of samples can produce consistent results in normal laboratory conditions.

(Source: U.S. EPA 1991.)

Contaminated storm water runoff from some mining operations has been documented as causing water quality degradation. In the past, storm water discharges received limited emphasis under the NPDES program. However, EPA promulgated regulations (55 FR 47990; November 16, 1990) that specifically address point source discharges of storm water from industrial facilities, including active and inactive/abandoned mine sites. These regulations require NPDES permits for all point source discharges of contaminated storm water from mine sites. Storm water requirements will be applied to mine sites either individually (i.e., through individual NPDES permits) or in larger groups (i.e., through general NPDES permits applicable to similar operations).

Some discharges from mine sites do not meet the traditional definition of a "point-source discharge." Specifically, runoff from tailings piles, overburden and mine development rock piles, and other mine areas often is not controlled through a discrete conveyance. As a result, these types of discharges have frequently been considered nonpoint-source discharges. Under the Section 319 of the CWA, States have been required to prepare nonpoint-source assessment reports and to develop programs to address nonpoint sources on a watershed-by-watershed basis. Each State must report to EPA annually on program implementation and resulting water quality improvements.

1.7.1.3 Clean Air Act

Under the CAA (42 USC § 4209, Section 109), EPA established national primary and secondary ambient air quality standards for six "criteria" pollutants. These are known as the National Ambient Air Quality Standards (NAAQSs). The NAAQSs set maximum concentration limits for lead, nitrogen oxides, sulfur dioxide, carbon monoxide, suspended particulate matter of less than 10 microns in diameter, and ozone. To attain the air quality goals set by the CAA, States and local authorities were given the responsibility of bringing their regions into compliance with NAAQSs. In addition, States may promulgate more stringent ambient air quality standards. EPA also has promulgated air quality regulations that specifically address smelting operations. Since this report does not evaluate mineral processing, no further discussion of those rules are found in this report.

New Source Performance Standards, authorized under CAA §111, also have been promulgated for metallic mineral-processing plants (40 CFR §60(LL)). A processing plant is defined as "any combination of equipment that produces metallic mineral concentrates from ore; metallic mineral processing commences with the mining of the ore." However, all underground processing facilities are exempt from the NSPSs. Also, NSPS particulate emission concentration standards only apply to stack emissions. NSPSs require operations to contain stack-emitted particulate matter in excess of 0.005 grams per dscm. In addition, stack emissions must not exhibit greater than 7 percent opacity, unless the stack emissions are discharged from an affected facility using a wet scrubbing emission control device. However, on or after 60 days following the achievement of the maximum production rate (but no later than 180 days after initial startup), operations must limit all process fugitive emissions (meaning fugitive dust created during operation though not released through a stack) to 10 percent opacity.

Prevention of Significant Deterioration (PSD) provisions of the CAA are intended to ensure that NAAQS are not exceeded. Under this program, new sources are subject to extensive study requirements if they will emit (after controls are applied) specified quantities of certain pollutants. Few mining sites are subject to PSD requirements since they typically are not predicted to emit sufficient quantities.

State ambient air standards promulgated to meet or exceed Federal NAAQSs are generally maintained through permit programs that limit the release of airborne pollutants from industrial and land disturbing activities. Fugitive dust emissions from mining activities may be regulated through these permit programs (usually by requiring dust suppression management activities).

Currently, only the six criteria pollutants are regulated by NAAQS. Several other pollutants are regulated under National Emission Standards for Hazardous Air Pollutants (NESHAPs). NESHAPs address health concerns that are considered too localized to be included under the scope of NAAQSs.

Under the 1990 Amendments to the CAA, Congress required EPA to establish technology-based standards for a variety of hazardous air pollutants, including cyanide compounds. In November of 1993, EPA published a list of source categories and a schedule for setting standards for the selected sources. Furthermore, if a source emits more than 10 tons per year of a single hazardous air pollutant or more than 25 tons per year of a combination of hazardous air pollutants, the source is considered a "major source." Major sources are required to use the maximum available control technology (i.e., BAT) to control the release of the pollutants (CAA Section 112).

1.7.2 Department of Interior

1.7.2.1 Bureau of Land Management

Most gold mining operations on Federal lands are conducted on mining claims located pursuant to the General Mining Laws. Under the 1872 Mining Law, a person has a statutory right to go upon the open (unappropriated and unreserved) public lands of the United States for the purpose of prospecting for, exploring, developing, and extracting minerals. Once a person has made a valuable mineral discovery and has properly located the claim pursuant to the mining laws, the person has broad possessory rights to develop the minerals upon which the claim was based.

Because of the broad nature of the claimant's possessory rights, the Federal agencies having management responsibilities over the lands upon which the claim is located cannot, in most cases, wholly restrict mining operations. Nonetheless, the surface managing agency can subject the mining operations to reasonable regulation to prevent "unnecessary and undue degradation" of Federal lands.

All mining claims located on lands managed by the BLM are subject to BLM regulation to prevent "unnecessary and undue degradation" of the Federal lands and resources involved. The BLM's authority to regulate mining claim operations under this regulation derives from the Federal Land Policy and Management Act of 1976 (FLPMA), the statute which sets out the BLM's general land management and planning authority. Exploration sites are subject to the less-than-5-acre exemption or must submit a plan of operation if greater than 5 acres.

The BLM's general surface management regulations governing mining claim operations, which include gold mining operations, are found at 43 CFR Part 3809. These regulations cover general design, operating and reclamation standards, monitoring requirements, bonding requirements, environmental review requirements, and remedies for noncompliance. They establish three general use categories for mining operations, each eliciting different levels of oversight by the BLM. These categories are (1) casual use operations (i.e., those that normally result in only negligible disturbances of Federal lands and resources and that require no prior notice to or approval from the BLM), (2) notice-level operations (i.e., those that involve disturbances of 5 acres or less for which the operator must notify the BLM prior to commencing surface disturbing activities), and (3) plan-level operations (i.e., disturbances of greater than 5 acres, and operations in some specified areas, for which the operator must obtain BLM approval of a plan of operations prior to commencing activity).

All operations, including casual use and operations under either a notice or a plan of operations, must be conducted to prevent unnecessary or undue degradation of the Federal lands. All operations must also be reclaimed and must comply with all applicable State and Federal laws, including air and water quality standards such as those established under the CAA and the CWA.

All mining operations are subject to monitoring by the BLM to ensure that they do not cause unnecessary or undue degradation, and that all operators are responsible for fully reclaiming the area of their claim.

The current BLM policy for bonding was established by an internal Instruction Memorandum (IM) issued on August 14, 1990 (U.S. DOI, Bureau of Land Management 1990a). Under this IM, the BLM will not require bonds for most casual use or notice-level operations. However, a 100 percent reclamation bond will be required from all operators who have established records of noncompliance. Additionally, the IM requires the posting of a 100 percent reclamation bond for all operations that use cyanide or other leachates and discharge cyanide-bearing tailings or fluids to impoundments or tailings ponds. The 100 percent bonding requirement applies only to those portions of the operation encumbered by cyanide facilities.

All plan-level operations, regardless of operation type (e.g., strip, open-pit, dredge, and placer) will be required to post a bond. Bond amounts are to be set at the discretion of the BLM (up to $2,000 per acre, except as noted above), depending on the nature of the operation, the record of compliance, and whether it is covered by a satisfactory State bond.

By another internal IM issued on August 6, 1990 (U.S. DOI, Bureau of Land Management 1990a), the BLM established uniform standards for surface management of mining operations that use cyanide and other chemical leaching methods for mineral extraction on public lands. This IM directs BLM Area and District offices to inspect all cyanide operations at least four times a year. All facilities employing cyanide leaching techniques must be fenced and must ensure protection of the public, wildlife (including migratory birds), and livestock. All operations must use the Best Practicable Technology (BPT) and must meet at least the following standards:

- Facilities must be designed to contain the maximum operating water balance in addition to the water from 100-year, 24-hour storm event. Containment ponds must be included in all containment systems.

- Tanks containing lethal solutions must be bermed to contain the maximum tank contents in the event of catastrophic tank failure.

- Facilities must be constructed so that solution containment is maximized.

- Leakage detection and recovery systems must be designed for heap and solution containment structures. Monitoring of ground and surface water through closure and final reclamation is required.

- Cyanide solution and heaps must be neutralized or detoxified.

- Surface disturbances must be minimized.

- Engineering designs, maps, and cross sections of the leaching facilities must be submitted as part of operating plans. Ground water and soil mechanics information is required for review of the designs.

These minimum standards must be met by all operations under mining claims on BLM land that use cyanide leaching techniques, unless an equally effective standard is set and enforced under State law. The authorized officer may waive certain of these minimum standards for existing operations in limited circumstances and only when the operations are not resulting in unnecessary or undue degradation or causing other unacceptable results (such as unauthorized discharges or avian mortalities). The BLM will supplement these minimum criteria through the development of State and/or district or resource area plans, as appropriate.

Mining claims located in BLM wilderness study areas are generally subject to stricter regulation than other mining claims. The regulations covering mining in wilderness study areas are found at 43 CFR Part 3802. The IM discussed above for cyanide management applies to relevant operations in wilderness study areas in addition to the 43 CFR Part 3809 regulations.

The BLM has the authority to issue leases for gold on certain acquired (as opposed to public domain) lands. Although this is rarely done, such leases would be covered by the general regulations applicable to hardrock leasing found at 43 CFR Part 3500.

1.7.2.2 National Park Service and Fish and Wildlife Service

Generally, location of new mining claims is prohibited in most areas managed by the NPS and the FWS. Regulations at 36 CFR Part 9 govern activities on land managed by the NPS under patented and unpatented mining claims already in existence prior to the time the lands were included with units of the NPS. On the other hand, the regulations at 50 CFR Part 29 govern mining activities under mineral rights on lands managed by the FWS that were vested prior to the acquisition of the land by the United States. As of 1989, mining activities were being conducted in 14 refuges under the jurisdiction of the FWS, 8 of which were in Alaska (Kilcullen 1990).

1.7.3 Department of Agriculture; Forest Service

Although the BLM has general management authority for the mineral resources on FS lands, the BLM regulations governing activities under mining claims do not apply to units of the FS. Instead, surface uses associated with operations under mining claims on FS lands are governed by the FS regulations in 36 CFR Part 228, Subpart A. The FS regulations generally mandate that operations under mining claims be conducted to minimize adverse environmental impacts on FS surface resources.

The FS regulations are similar to the BLM regulations and provide for FS consultation with appropriate agencies of the U.S. DOI in reviewing technical aspects of proposed plans of operation. However, the FS regulations differ in that the general use categories do not specify acreage, as opposed to the BLM's, where the use category is based on the acreage disturbed. The FS regulations require that persons proposing to initiate any operations that might disturb surface resources must file a notice of intent to operate with the district ranger with jurisdiction over the area to be affected. If the district ranger determines that the operations will be likely to cause significant disturbance of surface resources, the operator must submit a proposed plan of operations. Neither a notice of intent to operate nor a proposed plan of operations are required for the locating or marking of mining claims; mineral prospecting or sampling that will not cause significant surface disturbance; operations that do not involve the use of mechanized equipment or the cutting of trees; or uses that will be confined to existing roads.

The proposed plan of operations must include a thorough description of the proposed site, the nature of the proposed operations, and measures for meeting environmental protection requirements. Operations must comply with applicable environmental laws and must, where feasible, minimize adverse environmental effects on FS resources. The FS will conduct an environmental assessment of the proposed plan of operations and, if necessary, prepare a National Environmental Policy Act (NEPA) environmental impact statement.

The regulations specify standards for reclamation and provide that the district ranger may require a reclamation bond to cover the cost of reclamation. Where State bonding regulations exist, the FS has established memorandums of understanding with the States to prevent double bonding. In these cases, the bond amount must meet the more stringent standard, whether it is that of the State or the FS. Regulations specific to mining operations on FS Wilderness Areas are found at 36 CFR Part 293.

1.7.4 Army Corps of Engineers

Gold mining operations that fall within the jurisdiction of Army Corps of Engineers include placer mines, which have a great potential to physically restructure wetlands or "navigable waters." Until 1986, most placer mining activities were regulated by the Corps, under Section 404 of the CWA, through permits for the discharge of dredged materials. In 1986, the Corps and EPA entered into an agreement (updated in 1990) on the definition of "fill material" for 404 permitting. The agreement provided that jurisdiction of placer mining discharges would be determined on a case-by-case basis. Since then, the Corps has been responsible only for dredge and fill activities accessory to mining operations. These activities include construction of sediment ponds and roads, filling of dredge pits, etc., and are regulated nationwide through permits issued by the Corps.

1.7.5 STATE REGULATIONS

1.7.5.1 Nevada

Nevada has regulatory requirements controlling gold mining activities. Some of the regulations are a result of Federal program delegation (e.g., NPDES), while others were developed under Nevada statutes (e.g., reclamation).

In Nevada, 80 to 90 percent of mining operations are located on BLM or FS land. According to a State official, Nevada considers the Federal Government's role as a land owner to be no different from the role of any other land owner (Taff 1991). Although Federal agencies like the BLM and FS have the authority to manage the resources on their land, the State does not believe they have the authority to supersede State regulations designed to protect the environment as a whole. Nevada considers its regulation of mining, including operational permitting and reclamation requirements, to be part of its efforts to protect general environmental quality, especially water quality. Therefore, operations located on Federal lands must comply not only with the BLM or FS operating and reclamation requirements, but also with State operating and reclamation permitting requirements and general air and water quality regulations.

More specifically, an operation on Federal land must obtain both an operating permit from the State and "notice" or "plan of operations" approval from the appropriate Federal agency (see the BLM and FS discussion above for specifics regarding when "notice" and "plan of operations" are required). Similarly, operations located on Federal land must obtain State "reclamation permits" (separate from operating permits), and must also comply with BLM/FS reclamation requirements. However, specific attention has been given to facilitate compliance with both State regulations and the BLM and FS regulations. For instance, State permits incorporate most of the BLM and FS requirements. For this reason, and because State permit requirements are more comprehensive than those promulgated by the BLM and FS, a State permit is considered by the BLM and FS to be adequate proof that all their own requirements have been met (Taff 1991). However, the appropriate Federal agency performs comprehensive analysis, the results of which are incorporated into the permit. The specific State regulations governing gold mining operations are discussed below.

Reclamation

Although the State's operating permits contain some reclamation requirements (such as the stabilization of tailings and closure planning), reclamation permits address, in greater detail, the specific closure procedures the operator agrees to undertake. Specific requirements are applied on a case-by-case basis but generally include revegetation and containment of all wastes to prevent runoff and erosion. Both operating permits and reclamation permits require facilities to submit closure plans for process component sources (defined as any distinct portion of a facility that is a point source) at least 2 years before the anticipated closure of the source (Nevada Administrative Code 1989).

Reclamation regulations that became effective on October 1, 1990, require all existing exploration projects and mining operations to obtain a reclamation permit no later than whichever is earlier: October 1, 1993, or abandonment of the project. All new exploration projects and mining operations must obtain a permit prior to beginning operations. Each reclamation plan must identify a proposed postmining land use for the area that will be disturbed by operations and must describe the manner in which the disturbed area will be reclaimed to a condition that will support the proposed postmining land use.

In addition, each reclamation permit must be supported by a reclamation surety. The regulations identify several forms of surety that are acceptable. The amount of the reclamation surety is determined by estimating the actual cost to the Government agency of implementing the proposed reclamation plan.

Nevada regulations now require all surface mines to purchase reclamation bonds. Existing mines, however, had until 1993 to purchase bonds. Under a memorandum of understanding between the State, the FS, and the BLM, mining operations in the State on Federal land may have either the State, the BLM, or the FS designated as the holder of the reclamation surety. This prevents double bonding on Federal lands. However, when operations have the BLM or FS as the surety holder, the State retains the right to evaluate the surety amount for adequacy and may require additional surety if it is found to be insufficient to ensure reclamation. The State calculates the bond amount based upon the potential estimated cost to the agency of reclaiming the site if the operator fails to complete reclamation and based on the operator's record of compliance (Taff 1991).

Water Quality

Nevada regulates the discharge of pollutants, including suspended solids, from mining activities under a federally approved NPDES program. The State program requires pollution control permits for heap leach operations and mill dischargers (Miereau 1991). Pollution control permits prohibit the discharge of process fluids or liquid waste streams from these facilities during operation and closure activities. To obtain a pollution control permit, a facility must incorporate Best Management Practices (BMPs), including double-lined ponds or clay-lined tailings impoundments, into its design. Also, the placement of waste rock and tailings must be such that the potential for leaching is minimized. The State did approve a "319" Nonpoint-Source Pollution Management Program. It has drafted BMPs, but no regulations.

In addition, Nevada allocates water rights by establishing preferred uses of water within designated ground water basins. Mining is considered a preferred use for certain ground water basins. However, to access water reserves, mining operations must obtain a special appropriation permit to withdraw a certain amount of ground water or surface water from a particular basin. The State limits total withdrawals from any given basin to the annual recharge or "perennial yield" of the basin (Jessup 1988).

As of September 1, 1989, all existing mining facilities were given 3 years from that date to obtain operating permits (Nevada Administrative Code 1989). After July 1, 1990, all new onsite construction or modification projects were required to obtain permits. Permit applications require a plan of operations, hydrogeologic studies, assessment of impact to surface and ground water, methods for the control of storm water, notification of disposal sites for spent ore, etc. However, pilot facilities, small-scale operations (less than 10,000 tons of ore chemically processed per year or no more than 30,000 tons total per mine lifetime), and placer operations that rely exclusively on physical separation methods may file an abbreviated permit application. Permits also require stabilization of tailings and spent ore. Tailings and impoundment materials must be sampled and characterized once the impoundment is no longer active. In addition, mining operations are required to leave tailings impoundments in a state that is not hazardous to wildlife. Spent ore from cyanide leaching methods must be rinsed until weak acid dissociable (WAD) cyanide levels in the effluent rinse water are less than 0.2 mg/l, the pH of the effluent rinse water is between 6 and 9, and any runoff from spent ores piles would not degrade the waters of the State.

As part of the Water Pollution Control Permit, mines report quarterly on results of meteoric water mobility testing and waste rock analysis to determine the acid-generating potential of waste rock. The meteoric mobility test is an extraction procedure. The extracted solution is analyzed for nitrate, phosphorous, chloride, fluoride, total dissolved solids, alkalinity, sulfate, and metals. Waste rock analysis is intended to determine the net acid generation potential of the material placed in the waste rock dump during a quarter. Samples are collected daily during the quarter and classified based on their net carbonate value as sulfate: highly basic, basic, slightly basic, neutral, slightly acidic, acidic, and highly acidic. The quarterly composite sample to be analyzed is prepared on a tonnage weighted average for each classification and aggregated prior to analysis.

Air Quality

Nevada's ambient air quality standards meet, but do not exceed, Federal requirements, with the exception of the ambient standards for the Lake Tahoe area. For this area, the State has promulgated standards for ozone and carbon monoxide that are tougher than those required by EPA (Jessup 1988). Air quality permits must be obtained for the construction and operation of any new sources. An evaluation must be submitted by the applicant prior to the issuance of a registration certificate for a new or modified point source. This evaluation must include an estimate of air quality after construction of the proposed facility to ensure that ambient air quality will be maintained. In addition, Nevada's air quality regulations contain emission limits for specific mining companies, including several precious metal mining operations. Under Nevada Administrative Code (445.430-445.846), Point-Source Particulate Permits are required. These permits cover fugitive dust from construction and operation activities.

1.7.5.2 South Carolina

South Carolina has regulatory programs, including permitting and bonding, that control gold mining activities. Some programs are delegated by the Federal government while others are under the authority of South Carolina statutes.

Operating Permits

Under the South Carolina Mining Act (Section 48-20 of the State Code), the Division of Mining and Reclamation of the Land Resources Commission (LRC) is charged with ensuring that lands and waters involved in mining are protected and restored to the "greatest practical degree." LRC's responsibilities include issuing mining and reclamation permits, reviewing and approving reclamation plans, collecting reclamation bonds, and inspecting facilities to ensure compliance. LRC coordinates its activities with and supplements the regulatory activities of the Department of Health and Environmental Control (DHEC). As amended in 1990, the Act states clearly that reclamation requirements for a mine facility are part of closure. Annual reclamation reports are required by LRC and are also required through construction permits issued by DHEC. The South Carolina Mining Act, as amended in 1990, gives the LRC authority to assess civil penalties for noncompliance with the approved reclamation plan or schedule of reclamation. Penalties up to $1,000 per day per violation are authorized.

Operating permits are required for all surface mining activities with excavations exceeding 1 acre in area (South Carolina Code of Regulations 1980). Permits require submittal of site location and hydrogeologic information, facility construction plans, and containment system plans (e.g., settlement ponds and terraces). Reclamation plans are also required with any operating permit application. Reclamation is not required where infeasible for particular areas, provided steps are taken to minimize the extent of the disturbance.

Reclamation

Reclamation bond amounts are set at the discretion of the DHEC. To obtain bond release, mining sites must be revegetated, slopes must be graded, and a useful purpose established for any water impoundments.

Water Quality

South Carolina's Bureau of Water Pollution Control (WPC) within DHEC is charged with protecting surface and ground waters of the State. The Bureau's authority stems from the Clean Water Act (CWA) and the South Carolina Pollution Control Act (PCA). Applicable regulations include: SC Regulation 61-9 (NPDES Permits), SC Regulation 61-68 (Preparation and Submission of Engineering Reports), SC Regulation 61-68, -69 (Water Classification and Standards), and SC Regulation 61-71 (Well Standards and Regulations).

The Bureau's authority over mining facilities extends as long as there are potential impacts to surrounding waters, from construction through post-closure. The Bureau's program is implemented through permitting systems, violation of which can result in the issuance of consent orders or administrative orders as well as civil and criminal actions. The Bureau issues NPDES permits for surface water discharges, as well as construction permits for facility components, which include ground-water monitoring requirements.

South Carolina has an EPA-approved NPDES program and regulates effluent discharges accordingly. The State discharge limits are the same as the Federal guidelines. In addition to classifying surface waters according to expected use, the State has ground water classifications that are intended to maintain ground water quality. The State classifies all ground water as "Groundwater B" (GB), meaning that it must be suitable for use as drinking water without pretreatment. State drinking water MCLs are the same as Federal MCLs. Two other classifications, one more stringent [Groundwater A (GA)] and one less stringent [Groundwater C (GC)], can be applied only upon petition by a private interest (Jessup 1988). However, the State official contacted knew of no instances where GA or GC classifications had been granted (Kennedy 1991). Mining operations are required to install monitoring wells to ensure that ground water quality standards are maintained.

To further protect water quality, DHEC issues construction permits for industrial waste water treatment systems, which include mining process waste water ponds and rinse systems for cyanide leaching operations. Construction permits also enforce DHEC's policy (no actual rules exist) of requiring operators to place impermeable liners or asphalt pads under tailings impoundments and leaching areas (Kennedy 1991).

Air Quality

South Carolina opacity requirements, which limit fugitive dust emissions from all sources including mining operations, are more stringent than Federal opacity requirements. DHEC's Bureau of Air Quality Control issues and enforces Air Emissions Permits under the South Carolina Pollution Control Act and State Regulation 61-62.1. Facilities are issued five-year operating permits and construction permits that establish emission limits for various units. In addition to these limits, the permit makes operators subject to applicable New Source Performance Standards for Metallic Mineral Processing (40 CFR Part 60, Subpart LL). The permit may also require that dust from haul roads and turnaround areas be controlled by water sprays and water trucks and that stockpiles or waste rock piles be sprayed with water when wind erosion creates excessive emissions. The Bureau of Air Quality Control is authorized to seek civil and/or criminal penalties when permit requirements are violated by a facility. Formal facility inspections are conducted by DHEC on an annual basis.

Solid Waste

Under State law, mining wastes are currently excluded from regulation as solid waste. However, legislation that was under development, the Solid Waste Management Act, would broaden the State's definition of "industrial solid waste" to include materials that have been chemically altered, including wastes from cyanidation operations (Joy 1990). Operators would be required to obtain solid waste permits (separate from operating permits) for the disposal of such chemically altered mining wastes. Solid waste permits mandate controls for runoff water and require spreading and revegetation of the waste to prevent erosion (South Carolina Code of Regulations 1980).

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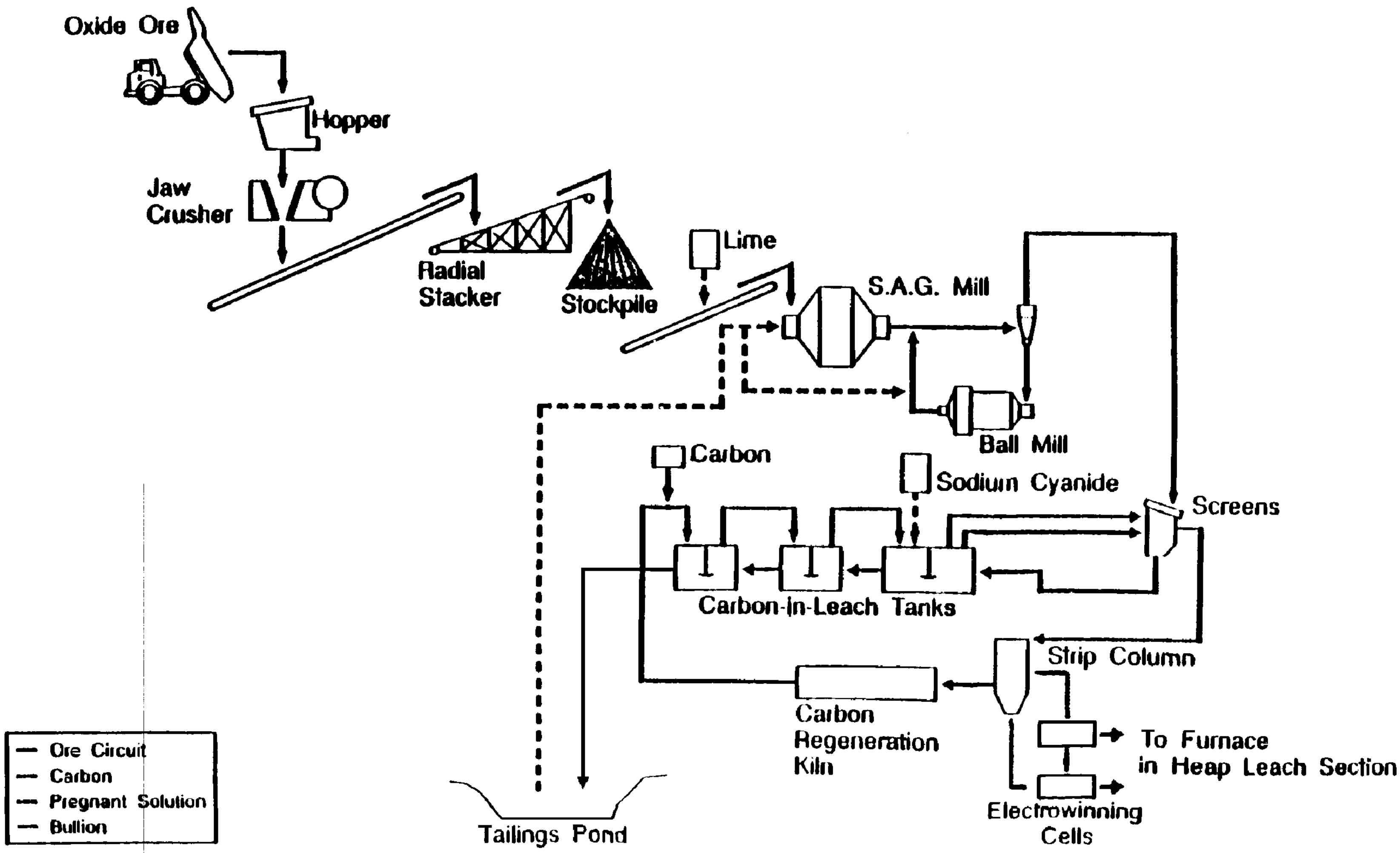
APPENDIX 1-A FLOW SHEETS OF SPECIFIC MINE OPERATIONS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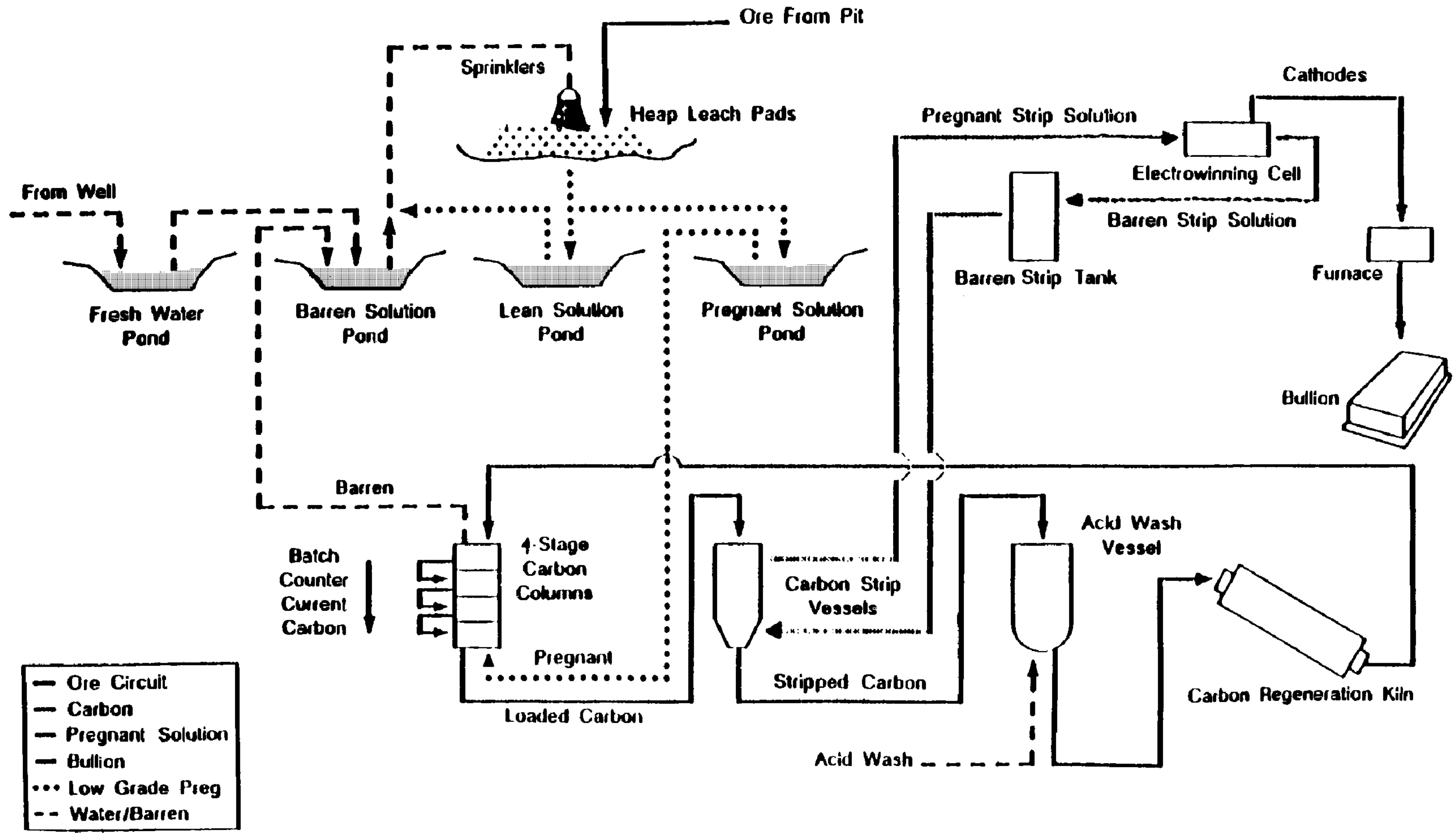
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Electrowinning Cell
Barren Strip Solution
Barren Strip Tank
Furnace
Bullion
Barren
Batch Counter Current Carbon
4-Stage Carbon Columns
Pregnant
Loaded Carbon
Carbon Strip Vessels
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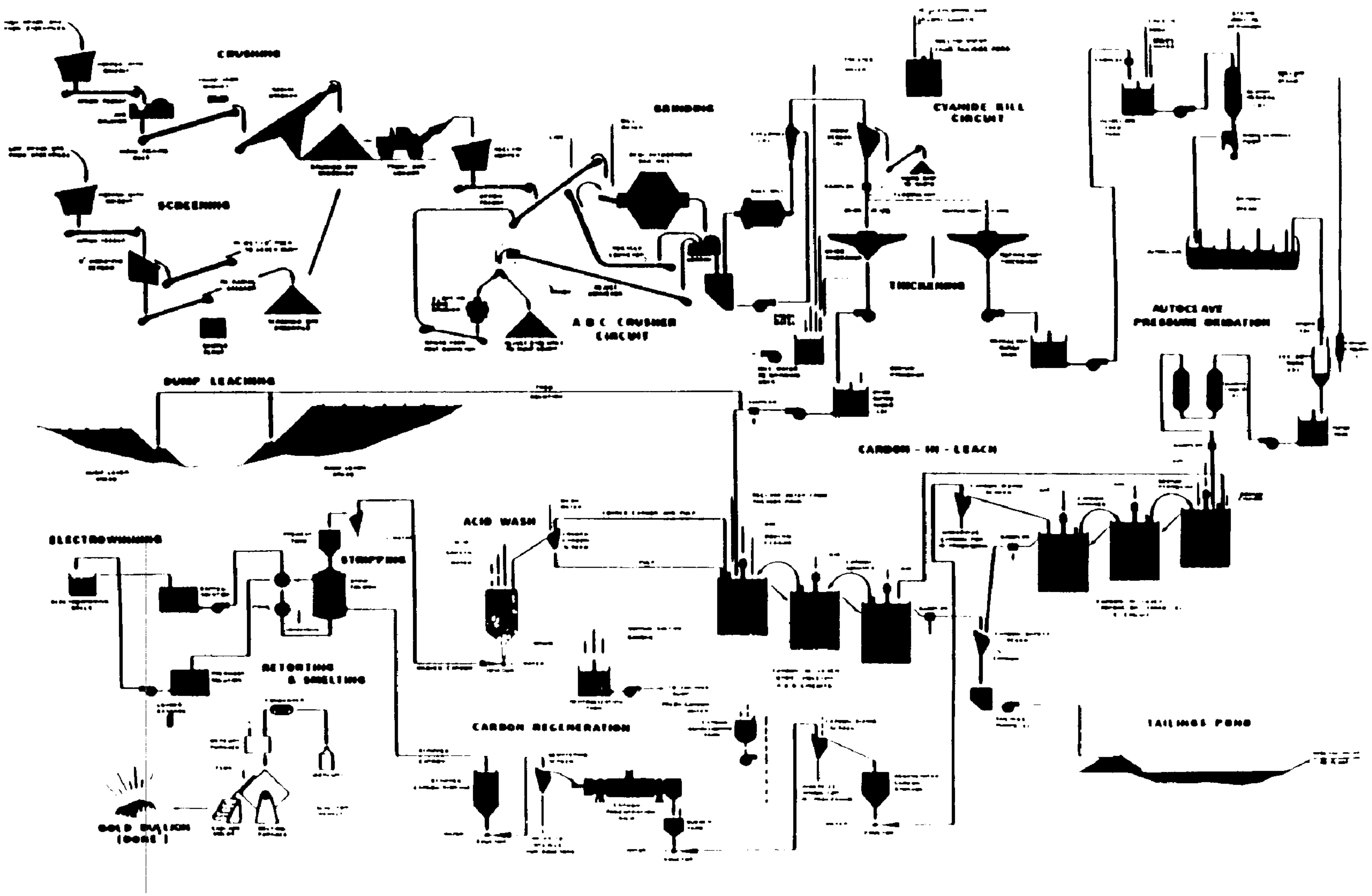
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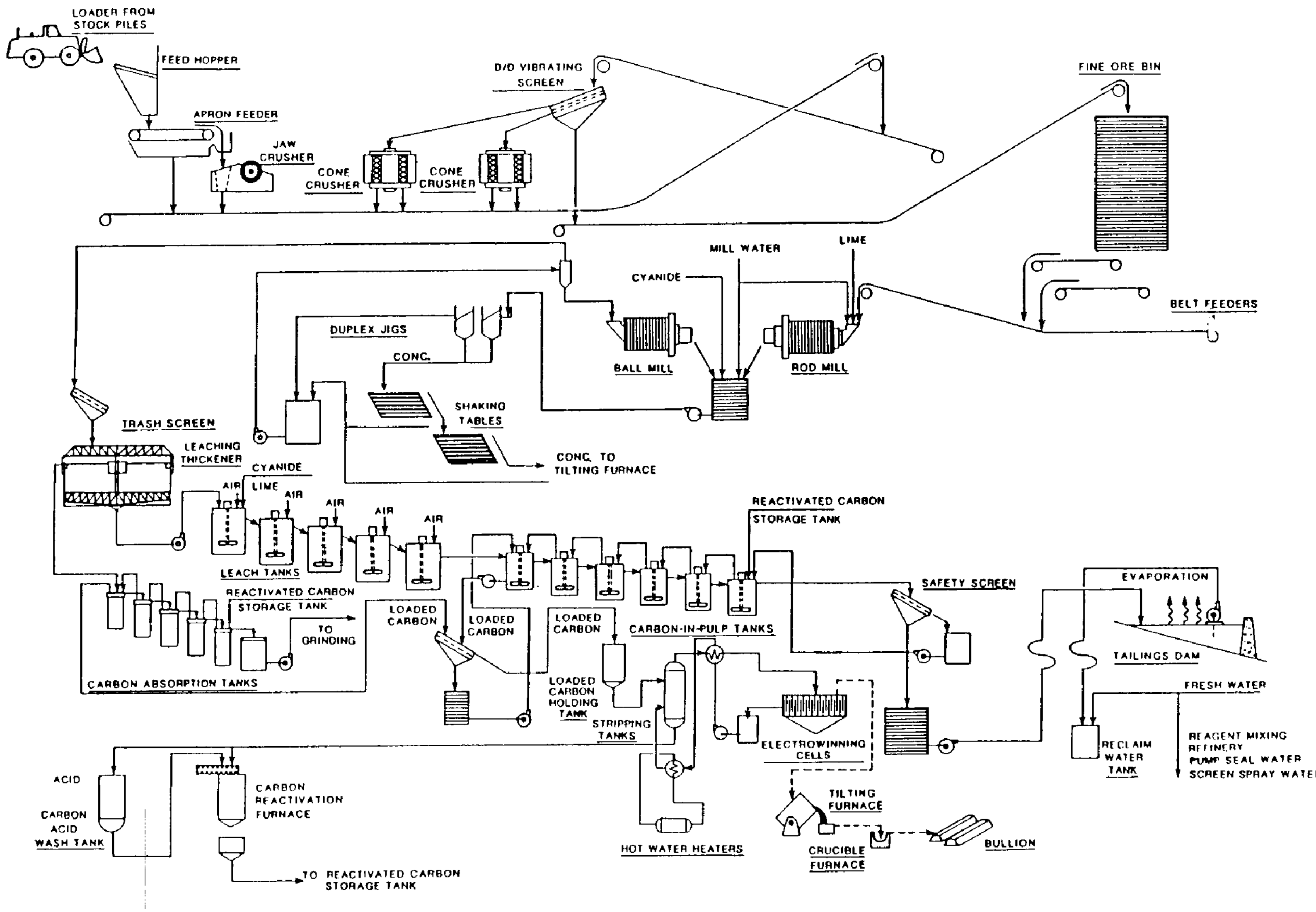
DUMP LEACHING
CARBON - IN - LEACH
ELECTROWINNING
STRIPPING
ACID WASH
RETORTING & SMELTING
CARBON REGENERATION
TAILINGS POND
GOLD BULLION (DORE)


LOADER FROM STOCK PILES
FEED HOPPER
APRON FEEDER
JAW CRUSHER
CONE CRUSHER
CONE CRUSHER
D/D VIBRATING SCREEN
FINE ORE BIN
MILL WATER
LIME
CYANIDE
BELT FEEDERS
BALL MILL
ROD MILL
DUPLEX JIGS
CONC.
SHAKING TABLES
CONC. TO TILTING FURNACE
TRASH SCREEN
LEACHING THICKENER
CYANIDE
LIME
AIR
LEACH TANKS
REACTIVATED CARBON STORAGE TANK
TO GRINDING
CARBON ABSORPTION TANKS
LOADED CARBON
LOADED CARBON
LOADED CARBON
CARBON-IN-PULP TANKS
REACTIVATED CARBON STORAGE TANK
SAFETY SCREEN
EVAPORATION
TAILINGS DAM
FRESH WATER
RECLAIM WATER TANK
REAGENT MIXING REFINERY PUMP SEAL WATER SCREEN SPRAY WATER
LOADED CARBON HOLDING TANK
STRIPPING TANKS
ELECTROWINNING CELLS
HOT WATER HEATERS
TILTING FURNACE
CRUCIBLE FURNACE
BULLION
ACID
CARBON ACID WASH TANK
CARBON REACTIVATION FURNACE
TO REACTIVATED CARBON STORAGE TANK

APPENDIX 1-B

NPL SITE SUMMARIES RELATED TO GOLD EXTRACTION AND BENEFICIATION

(from Mining Sites on the National Priorities List, Site Summary Reports, Volumes I-V, Environmental Protection Agency, June 21, 1991)

CARSON RIVER SITE, LYON AND CHURCHILL COUNTIES, NEVADA

Operating History

The Carson River Superfund Site is a 50-mile stretch of the Carson River in the Nevada counties of Lyon and Churchill. The site begins in Brunswick Canyon between Carson City and Dayton and extends downstream through the Lahontan Reservoir. This portion of the Carson River has been contaminated by mercury from the historical operations of approximately 100 gold and silver ore-processing mills. These mills lost an estimated 12 million to 18 million pounds of mercury to either mill tailings or direct discharges to the Carson River during their active lives in the late 1800's. Now, the tailings piles left behind discharge an estimated 8 million pounds of mercury annually to the river system. The Carson River site was proposed for the NPL in October 1989 and listed in August 1990.

Mercury is the contaminant of concern. The Carson River basin is a large recreational and commercial fishery resource. The basin is comprised of five hydrographic areas that include Carson Valley, Eagle Valley, Dayton Valley, Churchill Valley, and the Carson Desert, totalling about 3,365 square miles. The east and west forks of the Carson River arise in the Eastern Sierra, flow through an intricate irrigation system within the Carson Valley and then coalesce to form the mainstream of the Carson River. The river continues north through the Carson Valley, skirting the east side of Eagle Valley, then turns northeast to pass through Brunswick Canyon. Continuing east through Dayton Valley, the river flows into Churchill Valley, site of the Lahontan Reservoir, the main water storage reservoir of the Newlands Irrigation Project. Below Lahontan Dam, a complex system of canals and drains facilitate irrigation within the Carson Desert. The river and irrigation return flow ultimately flow northeast to the Stillwater National Wildlife Refuge and the Carson Sink, or south to Carson Lake.

An estimated 700,000 people annually use the river system for recreation, fishing, and irrigation. Approximately 1,200 acres of food and forage crops are irrigated by water from the 50-mile stretch of the Carson River in the NPL site. The river is not used for drinking water. The Dayton Valley Estates Water Company services 139 homes with water from an underground aquifer. The wells are 1.25 miles from mercury-contaminated tailings piles. In the Dayton Valley area, at least 226 households served by private wells are within 3 miles of either the Carson River or a mercury-contaminated tailings pile. At least 30 of these homes are within 2,000 feet of either the Carson River or a contaminated tailings pile.

The Carson River Site consists of sediments in the river and tailings piles associated with historical milling operations along the river. Mercury-contaminated tailings piles have been found 5 miles up Brunswick Canyon, 3 miles up Six Mile Canyon, and within the Carson Plains. Areas near the Comstock Load, where extensive mining occurred, such as in Gold Canyon, may also be major potential sources of mercury-contaminated mine tailings piles. Annual rains transport mercury from the tailings piles to the Carson River.

The Nevada Department of Environmental Protection (NDEP) sampled one tailings pile located near Six Mile Canyon in May 1986. The tailings pile was estimated to be approximately 100 feet long, 15 feet wide, with an average of 4 feet high, with mercury contamination of 493 ppm. The volume of contaminated material is estimated to be 222 cubic yards. For Hazard Ranking System (HRS) purposes, only one tailings pile was sampled to define the waste quantity for the Carson River Superfund Site. According to the NDEP, this tailings pile is one of hundreds of mercury-contaminated tailings piles known to exist in Brunswick and Six Mile Canyons. Because of the large number of known contaminated piles, and because of the large amount of mercury lost during the milling process, the waste quantity estimated from the one sampled tailings pile is expected to vastly underrepresent the total waste quantity at the site.

A Remedial Investigation and Feasibility Study (RI/FS) for the Carson River site was initiated in September 1990. EPA's immediate priority was to analyze the options for the stabilization and containment of the tailings piles. In addition, EPA is searching historical mining claims and land ownership titles for Potential Responsible Parties.

Because of the historical nature of the mining operations which resulted in the mercury contamination, there is little information available on the operating history of the site. During the late 1880's, ore mined from the Comstock Lode near Virginia City was transported to any of 75 mills, where it was crushed and mixed with mercury to amalgamate the gold and silver. Because water power was available, 12 mill sites in the Brunswick Canyon area of Carson River dominated. It is not known when operations at the mills ceased; however, the peak discharge reportedly occurred in the 30-year period from 1865 to 1895. The mills have since been demolished.

Liquid mercury was imported and used in the amalgamation of gold and silver in the ratio of 1:10, mercury:ore. The average loss of mercury was 0.68 kg for each ton of ore milled. EPA estimates that during the operation of these mills an estimated 14 million to 15 million pounds of mercury were lost, of which only 0.5 percent was later recovered. Currently, an estimated 8 million pounds of mercury-contaminated sediments are discharged annually from the tailings piles.

From 1906 to 1914, quicksilver was recovered from tailings at Douglas Mill in Six Mile Canyon. The unknown operators of the quicksilver mine recovered approximately 75,000 pounds of mercury using cyanide and flotation. Later, the Alhambra Mine Company also attempted to recover mercury from contaminated waste piles. Alhambra used a cyanide leaching process to recover gold, silver, and mercury. Alhambra's reprocessing operation lasted from December 1984 to July 1986; it is unknown how much gold, silver, and mercury it recovered.

The Lahontan Reservoir has trapped Carson River sediments since it was constructed in 1915, acting as a sink for mercury-contaminated sediments. It has not been determined if areas below the dam will be included in the RI/FS. It is possible that the results from an ecological assessment of the area below the dam will request the inclusion of this area in the Carson River Superfund Site. The Carson River and the Lahontan Reservoir are owned by the State of Nevada. The ownership of land adjacent to the river is unknown but may be determined through a review of mining claims.

Environmental Damages and Risks

Neither the preliminary assessment nor the HRS worksheets discuss any known human effects associated with mercury, the contaminant of concern. Possible exposure pathways are soil, air, ground and surface water, and the food chain.

The greatest toxicological concern is methyl mercury, which is obtained from the consumption of fish. The major source of methyl mercury in the environment is via microbiological conversion of inorganic mercury by methanogenic bacteria in sediments of aquatic ecosystems. Organic mercury is 90 percent absorbed through the gastrointestinal tract and easily crosses the skin barrier. Once absorbed, organic mercury is mobile in the body, readily crossing into the brain as well as into a fetus. Organic mercury is slowly broken down and excreted through feces. The halflife of organic mercury is 65 days.

During summer 1981, fish were collected to determine the mercury concentration in fish tissues. Results indicated that significant mercury accumulation is occurring within fishes of the Lahontan Reservoir. Mercury concentrations in muscle tissue ranged from 0.11 mg/kg in young-of-the-year white bass to 9.52 mg/kg in striped bass. Of the 53 muscle tissues analyzed, 36 (68 percent) exceeded the 1 mg/kg "action level" considered safe by the Food and Drug Administration. Mercury concentrations in heart tissues ranged from 0.17 mg/kg in carp to 5.58 mg/kg in striped bass. Liver tissues had mercury concentrations ranging from 0.21 mg/kg in brown bullhead to 23.65 mg/kg in striped bass. These levels are considerably higher than the 0.20 mg/kg considered as background for fish. In general, mercury concentration within species increased with fish weight.

In 1986 the Nevada Department of Wildlife and Consumer Health Protection Services issued a fish consumption advisory. The Department recommended that no more than one meal of fish (8 ounces) caught in the Lahontan Reservoir or outfall waters below the reservoir should be eaten each week because of possible toxicity from mercury. Specifically children or women of childbearing age should not consume any fish from these waters. The health advisory was expanded and reissued in 1987 to indicate that no more than one meal of fish per month should be eaten, and walleye more than 21 inches long should not be eaten.

Approximately 1,200 acres of food and forage crops are irrigated by the Carson River between Dayton and the Lahontan Reservoir. However, no studies indicate or describe the presence of mercury in food or forage crops.

Although water drained from the Lahontan Reservoir through canals is used mainly for irrigation, some canal water also drains into the Stillwater Marsh. Most of the water entering the marsh is reportedly irrigation return flows. The Stillwater Wildlife Management Area is a major breeding ground and stopover for hundreds of thousands of birds migrating on the Pacific Flyway. Fish and bird kills in the Carson Sink have been attributed to increased salinization of the water and possibly increased susceptibility of the wildlife to disease because of elevated levels of potentially toxic elements such as arsenic and selenium. Mercury was not detected at the Stillwater Marsh Reservoir outlet during NDEP sampling in 1983 and 1984.

CLEAR CREEK/CENTRAL CITY SITE; CLEAR CREEK AND GILPIN COUNTIES, COLORADO

Operating History

The Clear Creek/Central City historical hardrock mining site is one of the most mined areas in Colorado. Data indicate that up to 25 mines and 6 milling operations are operating in Gilpin and Clear Creek Counties. The area also includes more than 800 abandoned mine workings and tunnels. Mining activity in the Central City/Black Hawk area began in 1859 with placer gold mining. Exploration tunnels were built from 1860 to 1937. Mining operations have included gold, silver, copper, lead, and zinc. Although mining operations have varied recently because of fluctuating market prices, historically 85 percent of the mining has been for gold, 10 percent for silver, and 5 percent for copper, lead, molybdenum, and zinc.

The Argo Tunnel, the most extensive and probably the most complicated of the five tunnel/mine systems at the site, is an abandoned mine drainage and ore haulage tunnel. The Argo Tunnel is 4.16 miles long and is connected to eight major mining zones. There are a total of 36 laterals that branch from the Argo Tunnel, 10 of which connect to mine systems. It is estimated that there are 91 surface openings and 21,400 feet of vein strike associated with the Argo Tunnel system. In 1982, it was documented that the owner was using the tailings near the tunnel portal as decorative landscaping and was selling tailings samples to local distributors. The Argo mill site is also a local tourist attraction as it is listed in the National Register of Historic Places.

In 1943, four miners were killed because of a blowout in the Argo Tunnel caused by mining activities. In 1980, a second blowout occurred that was attributed to "natural" causes (i.e., the collapse of "roof falls" used for damming water). As a result of the 1980 blowout, Clear Creek was "grossly contaminated" and showed "serious violation of metal standards" the next day. (Note that extensive information was not available for the other tunnel/mine systems as it was for the Argo Tunnel.)

The Clear Creek/Central City site was nominated for the NPL in 1982 and added to the NPL in 1983. A removal action was conducted by EPA's Emergency Response Branch at the Gregory Incline in March 1987 to protect human health and the environment from hazards associated with the collapse of a retaining crib wall. EPA removed the wall, decreased the slope of the tailings pile to stabilize it, and then constructed a gabion-basket retaining wall.

Environmental Damages and Risks

The Phase II remedial investigation provided an assessment of the risks to human health associated with the Clear Creek site. Overall, risks to human health are not expected from ingestion of surface water when used as drinking water, ingestion of surface water while swimming, or ingestion of fish, based on the exposure scenarios evaluated in this assessment. Potential risks are associated with ingestion of ground water, incidental ingestion of tailings, and inhalation of airborne dust. Arsenic contributes most significantly to risks from ground water and tailings. All of the chemicals evaluated for the inhalation pathway pose risks to human health. Lead exposures from ingestion of soil, dust, and ground water pose potential risks to children.

It was determined during the site investigation that Clear Creek, between the Argo Tunnel and Golden, Colorado, "cannot support fish due to the contamination caused by mining activity." Contaminants of concern for aquatic life are aluminum, arsenic, cadmium, chromium, copper, fluoride, lead, manganese, nickel, silver, zinc, and low pH. During the Phase I remedial investigation, concentrations of these chemicals in Clear Creek, North Clear Creek, and in the wetland below National Tunnel were compared to Federal Ambient Water Quality Criteria (AWQC) or to the Lowest-Observed-Effect Level (LOEL). Criteria for aluminum, cadmium, copper, lead, manganese, silver, and zinc were exceeded in Clear Creek and North Clear Creek. In North Clear Creek, criteria for pH were also exceeded. In the wetland, criteria were exceeded for aluminum, cadmium, copper, manganese, silver, zinc, and pH.

The Phase II remedial investigation focused on the potential risks to trout and macroinvertebrates at the site. It was found that trout could be acutely affected in the mainstem of Clear Creek, North Clear Creek, and West Clear Creek, along with numerous tributaries of the streams. In addition, virtually all of the tunnel discharges are expected to be acutely toxic to fish.

In the mainstem of Clear Creek and several of its tributaries, trout are at moderate to high risk of adverse chronic (reproductive) effects. In North Clear Creek, there is a clear risk of adverse reproductive effects. Potential risks of adverse reproductive effects are high in West Clear Creek from Woods Creek to the confluence of Clear Creek. Chemicals in Lions Creek and Woods Creek are likely to cause chronic effects.

Zinc sediments could cause adverse reproductive effects in all stream segments that were evaluated. Arsenic, cadmium, copper, and lead in sediment pose chronic risks at some locations.

CIMARRON MINING CORPORATION SITE, CARRIZOZO, NEW MEXICO

Operating History

The Cimarron Mining Corporation Superfund Site is 10.6 acres of privately owned land approximately 1/4 of a mile east of Carrizozo, New Mexico, and approximately 100 miles south-southeast of Albuquerque. It was originally constructed to recover iron from ores. The facility was sold in 1979 and subsequently revamped to mill precious metals ore. The precious metal recovery facility consisted of a conventional agitation cyanidation mill that resulted in the discharge of contaminated liquids and stockpiling of contaminated tailings and waste trench sediment at the site. The mill operated without a State discharge permit. The mill was closed in July 1982 and the owners of the facility filed for bankruptcy in July 1983.

Cyanide is the primary contaminant of concern; however, several metals were also identified as contaminants of concern. Approximately 1,500 people live within 2 miles of the site. The Carrizozo municipal wells are located within 2 miles of the site and were estimated in 1985 to serve a population of 1,636. Contaminated media of greatest concern at the site are shallow ground water and surface soils. The site was added to the NPL on October 4, 1989.

While conducting the remedial investigation at the Cimarron site, the existence of another abandoned mill became known. The other location, known as Sierra Blanca, is 1 mile south of the Cimarron site. The two mills were owned by the same parent company (Sierra Blanca Mining and Milling Corporation) and, for a short period, operated concurrently. File information indicates a possible spill at Cimarron prompted the relocation of milling operations to Sierra Blanca. Investigation of the Sierra Blanca mill is being performed as a second operable unit.

The RI/FS was conducted between May 1989 and May 1990. In the Record of Decision (ROD) (September 1990), EPA announced the selected remedy for the site. The selected remedy will pump contaminated ground water from the shallow aquifer and convey it to the Carrizozo publicly owned treatment works (POTW) for treatment, thereby eliminating the potential for migration of contaminated shallow ground water to the deeper water supply aquifer. In addition, source control measures would be implemented.

The mill facility was used to mill iron ores and recover iron using a magnetic separator during the late 1960's and 1970's. Cyanide was not used in the original process and tailings from the mill were transported off site and used as fill material in the Carrizozo area.

In 1979, Southwest Minerals Corporation bought the mill site and apparently began using a cyanide process to extract precious metals from ores transported to the mill. Detailed information on the metals extraction process operating between 1979 and 1981 was not available to EPA during their remedial investigation. Cyanide was detected in an onsite discharge pit sediment sample collected by the New Mexico Environmental Improvement Division (NMEID) in 1980, which indicates that cyanide extraction was likely in operation at that time.

Southwest Minerals expanded the operation in 1981 even though they were operating without the required discharge permit. The mill ceased operation in July 1982 following the June 23, 1982, receipt of an NMEID notice of violations for discharging into a nonpermitted discharge pit. The State did not pursue legal actions against Southwest Minerals and the company filed for bankruptcy in July 1983.

The EPA interviewed former mill employees and examined the onsite equipment during the remedial investigation in order to summarize the precious metals recovery operations employed at the site after 1981.

Ore was transported to and stockpiled on the site before it was transferred to a jaw crusher for size reduction. After the ore was crushed, it was transferred to the mill building where it was placed in a large hopper. Hydrated lime was added to prevent production of hydrogen cyanide gas and to optimize the cyanidation reactions. The hopper fed a ball mill and rake classifier where cyanide solution was added to the ore.

Sodium cyanide and potassium cyanide (stored onsite in 220-pound drums) mixed with water composed the cyanide solution. In addition, two metal stripping chemicals (AMPREP and Enstrip 70), containing 15 percent potassium cyanide, less than 1 percent lead oxide, and nitro-aromatic compounds were apparently added to the cyanide solution to promote additional leaching of precious metals.

The cyanide solution was mixed in two large vats, gravity fed to a large holding tank, and subsequently pumped from this tank to the rake classifier, creating a cyanide-solution/crushed-ore slurry. From the rake classifier, the slurry was pumped to a heated, agitated vat. Heating the slurry promoted the reaction of cyanide with precious metals. The slurry was pumped to a second agitated vat and then to each of four thickeners. Pregnant (precious metal-containing) cyanide solution was skimmed from the top of each thickener and routed (countercurrent to the direction of slurry flow) back to the second agitated vat. Pregnant solution contained in the agitated vats was gravity fed to a large metal holding tank near the lab building.

Pumped from the holding tank, pregnant solution was fed through small pressure filters to an electrowinning cell in the lab building. Precious metals were deposited onto aluminum plates, which were heated in an outside kiln to separate the aluminum from the doré (unrefined metals).

The barren cyanide solution contained free cyanide and metal-cyanide complexes of copper, iron, nickel, cobalt, zinc, and other impurities. Most of the barren solution was pumped to two cement block-lined trenches near the main operations building for recycling into the mill circuit, but a portion was discharged to the unlined discharge pit to avoid build-up of metal impurities that would subsequently interfere with the dissolution and precipitation of gold in the cyanidation process. Backwash waste solution from the pressure filters was disposed of in the discharge pit. Chlorine was added to the waste solution to oxidize the cyanide. Analyses of samples from the pit indicate that this treatment was not effective. The ineffectiveness of the chlorine treatment was possibly because of poor application methods and/or the existence of a significant quantity of complex cyanide forms not affected by chlorine. The cement block trenches and the unlined discharge pit are the two main sources of cyanide migrating into the ground water at the site.

Solids from the last thickener in the series were pumped through a solid separator and were conveyed and discharged to a truck for transport to the tailings piles. The remaining fluid fraction (and small-size solids) were apparently gravity fed to the two cement block trenches for recycling into the cyanidation process. As sediment built up in the trenches, it was removed and stockpiled onsite.

Environmental Damages and Risks

Site contamination was revealed in the analyses of soil samples collected during a 1980 NMEID field inspection. This initial sampling revealed the presence of cyanide and elevated metals in shallow ground water, soil, and mill tailings. Additional investigations, including the RI/FS, delineated the extent of cyanide and metals contamination at the Cimarron site.

The June 1990 Remedial Investigation Report presents an endangerment assessment of the potential human health risks associated with the existing conditions at the site. Land surrounding the site is used for agricultural, commercial, recreational, and residential purposes. An estimated total population of 1,500 lives within a 2-mile radius of the site. The main mill facility is fenced to prevent access, including the tailings disposal area.

The total population served by ground water from the aquifer of concern within 3 miles of the site was estimated in November 1985 to be 1,636. This includes 1,500 people served by the town of Carrizozo municipal water system. The municipal supply wells are located within a 2-mile radius of the site. The closest drinking water well is located about 0.8 miles from the site. An onsite well was used for industrial purposes. The risk assessment identified cyanide and several metals as contaminants of concern.

The risk assessment determined that, under a current exposure (for an offsite resident) scenario, it is unlikely that human receptors will experience adverse noncarcinogenic health effects. The highest excess cancer risk for exposure resulting from site visits or inhalation of fugitive dust in Carrizozo is 4.7×10^{-8}.

The risk assessment determined that, under a future exposure (for an onsite resident) scenario, there may be concern for potential noncarcinogenic health effects in children or adults ingesting contaminated ground water. The highest excess cancer risk is 8.7×10^{-6} resulting from incidental ingestion of soils.

SILVER MOUNTAIN MINE, LOOMIS, WASHINGTON

Operating History

Underground mining for silver, gold, and copper began at the site in 1902. EPA's remedial investigation states that the mine was active in 1936, 1943, 1945, and 1956, and that by 1956 the mine had approximately 2,000 feet of underground mine workings and a few thousand tons of mine dump. A mill was built in 1952 but may have never been used. No other records of production were known to exist. From late 1980 to late summer 1981, Precious Metals Extraction (PME), Ltd., constructed and operated the leaching operation described above. This operation was abandoned in 1981 with no site closure or cleanup of contaminated material.

Detailed records on the process used by PME and the construction of the leach heap and leachate collection pond were not available to EPA during their remedial investigation. However, field observations and data collected by the Bureau of Mines during their investigation in 1989 provide basic data on the leaching process and unit construction:

"PME cleared an area of approximately 180 feet by 140 feet, adjacent to existing mine dumps. A leach pad base of sandy soil up to 3 feet thick and graded with a 2.5 percent slope to the southwest was prepared. At the southern end of the leach pad a rectangular trench 7 feet by 75 feet and averaging 4 feet in depth was dug as a leachate collection pond. The soil base and pond were then covered with a green 20-mil thick plastic liner. Another layer of sandy soil, from 0 to 6 inches thick was then placed over the plastic liner. Approximately 5,300 tons of material from the mine dump were loaded onto the pad. The prepared heap was approximately 100 feet long, 105 feet wide, and 14 feet high." As stated above, several tons of caustic soda and lime, and approximately 8,000 pounds of sodium cyanide were combined with water and applied to the leach heap.

Processing of the leachate to remove the precious metals may have been accomplished through direct electroplating or by using activated carbon, but information on the processing is not conclusive. Drums containing activated carbon were found onsite. The operation was abandoned in late summer 1981 without neutralizing the solution in the leachate pond or materials in the leach heap. Empty cyanide drums and large containers of activated carbon also remained onsite.

Environmental Damages and Risks

Initial interest in the site began in 1981, when the owner of the surface rights informed the Okanogan County Health Department of the heap leaching operation (U.S. EPA, Region X 1990a; Bowhay 1983). Originally, the Washington Department of Ecology responded to the threat caused by the cyanide in the leachate collection basin. Upon further investigation, EPA found additional potential sources of contaminants (the leach heap, mine dump, mine drainage, and bedrock) and additional contaminants of concern (arsenic and antimony, as well as cyanide).

The Remedial Investigation Report, completed in January 1990, presents a human health risk assessment for the site. The risk assessment identifies arsenic, antimony, and cyanide as the contaminants of concern. Population near the site is sparse, with fewer than 20 people within a 3-mile radius served by drinking water wells. The land in closest proximity to the site is used for cattle grazing. The closest domestic water well is approximately 3 miles south of the site. Currently, the closest livestock watering well is 2 miles from the site. Other concerns include use of the site by local teenagers who may potentially become exposed to the contaminants.

Arsenic, antimony, and cyanide are the major contaminants in water. Based on future exposure scenarios, exposure to arsenic in water could result in an increase in cancer risk of 2×10^{-4}. There is also risk of noncarcinogenic effects from arsenic, cyanide, and other chemicals.

The major contaminant in soil is arsenic. Based on future exposure scenarios, exposure to soil could result in an increased cancer risk of 2×10^{-3}, as well as noncarcinogenic effects.

WHITEWOOD CREEK SITE, LAWRENCE, MEADE, AND BUTTE COUNTIES, SOUTH DAKOTA

Operating History

Homestake Mining Co. initially began gold mining near Lead, South Dakota, in the late 1870's. Approximately 110 million tons of ore were produced during the operating history of the site. Mining operations extended to a depth of more than 8,000 feet below the land surface. The first milling operations used crude methods to crush the ore and recovered gold by gravity or by amalgamation with mercury. Mercury amalgamation was used primarily until 1971 when cyanide began to be used exclusively. It is estimated that between 1/8 and 1/2 ounce of mercury per ton of ore crushed was lost, with 50 percent of this being discharged in the waste stream.

Tailings and untreated waste water were continuously discharged into Whitewood creek during the 100-year operating history of the site, excluding a 5-year period during World War II when the mine was closed. Tailings were discharged directly into the creek or its tributaries from a number of mine operators until approximately 1920, after which Homestake was the only source of tailings discharge. The discharge of tailings was a common practice of the time. In 1963, up to 3,000 tons of tailings and 12,500 tons of water were being discharged per day into Whitewood Creek.

In the 1920's, ball and rod mills were brought into use at the mine. The ball and rod mills created finer-grained tailings, or "slimes." After 1935, sand-sized tailings were typically used to backfill mined areas, and the "slimes," as well as some coarse-grained sands, were discharged into Whitewood Creek. This practice continued until 1977. In 1977, Homestake constructed a tailings impoundment in the upper reaches of the watershed at Grizzly Gulch, located in the upper reaches of the Whitewood Creek watershed, to treat residual slimes and process waters. In December 1984, a waste water treatment system was put into operation to treat water from the tailings impoundment and the mine. The plant uses rotating biological contractors to remove cyanide and ammonia, iron precipitation and sorption to remove metals, and sand filtration to remove suspended solids from mine water. The solids are returned to the tailings pond and the water is discharged into Gold Run Creek, which runs into Whitewood Creek between the towns of Lead and Deadwood. This treatment was then supplemented to meet the newly imposed NPDES and State stream standards when Homestake began the research and development of a new waste water treatment plant using a bio-treatment process. This discharge is monitored to meet requirements of the CWA.

From the 1870's to the end of the century, a substantial portion of the discharged tailings were distributed in and on the alluvial materials of the floodplain because Whitewood Creek was a small meandering stream with insufficient capacity to transport the large quantity of tailings. Over time, the discharged tailings and some alluvial material filled the meanders of the creek, which straightened its channel and increased its gradient. This, in turn, caused Whitewood Creek to downcut its channel to the resistant shale bedrock, which today forms the channel bottom for most of the length of the 18-mile stretch of the site. As a result of the changes in the sediment-carrying capacity of Whitewood Creek, little deposition of tailings on the alluvial materials is believed to have occurred beyond the turn of the century.

Environmental Damages and Risks

Systematic studies of the Whitewood Creek area by the South Dakota Department of Health, which began in 1960, quantified the solids and cyanide loading to the creek and recommended further studies. In 1965, a study by the South Dakota Department of Game, Fish, and Parks determined that aquatic bottom organisms were not present in Whitewood Creek downstream from the waste discharges. Several additional studies, which focused on the possible serious environmental hazard created by mercury contamination, led to the discontinuance of mercury use in gold recovery operations in December 1970.

A study published in 1978 found arsenic concentrations ranging from 2.5 to 1,530 µg/l in ground water from areas with large tailings deposits. As a result of these studies, it was concluded that the Whitewood Creek area would remain highly contaminated until the discharge of tailings was discontinued. This resulted in the construction of Homestake's Grizzly Gulch Tailings Disposal Project, which became fully operational on December 1, 1977 and produced a dramatic improvement in the physical appearance and quality of the creek waters.

The potential lifetime excess carcinogenic risks from exposure to arsenic through ingestion of soils and ground water within the site for both the representative and maximum exposed site resident were determined to be unacceptable. For the representative and maximum exposed site resident, ground water risks were determined to be 1.9×10^{-4} and 4.4×10^{-3}, and soil risks were determined to be 2.4×10^{-4} and 2.6×10^{-3}, respectively, all of which are greater than the acceptable Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) level of 1×10^{-4}. Potential risks to recreational visitors were determined to be acceptable. The potential risk to the representative site resident from the consumption of ground water is acceptable when evaluated with respect to the National Primary Drinking Water Standard. The greatest potential risk to the representative site resident comes from surface soils on residential properties that have elevated arsenic levels rather than tailings deposit area soils or irrigated cropland soils. Elevated arsenic levels on residential properties are the result of past deposition or the use of tailings as road gravel.

Elevated arsenic concentrations in the downgradient alluvial ground waters present a possible future unacceptable potential risk. The current potential risk of these ground waters was not considered because they are not used as a water supply and a state regulation prohibits the installation of water supply wells within the 100-year floodplain of Whitewood Creek, within which these ground waters are situated.

Potential noncarcinogenic health effects associated with exposure to arsenic, cadmium, chromium, copper, lead, manganese, mercury, and nickel through the ingestion of soils and ground water within the site were determined to be unacceptable for the maximum exposed site resident. Effects for all other groups were determined to be within acceptable levels. The unacceptable level for the maximum exposed site resident assumed residency on the tailings deposit areas, the concomitant high rates of incidental ingestion of the soils in these areas, and the consumption of downgradient alluvial ground waters, scenarios not currently encountered by site residents but that could be encountered in the future.

APPENDIX 1-C

304(l) SITES RELATED TO GOLD MINING ACTIVITIES

Sunnyside Gold (Mayflower Mill)

The Mayflower Mill is an active operation that processes ore from the Sunnyside Mine, which produces gold and silver plus sulfides of lead, zinc, and copper. The waste water discharge from the mill has been identified as a point source that contributes significantly to contamination (e.g., high metals concentrations, primarily zinc, and whole effluent toxicity) in Cement Creek and the Animas River into which the creek flows. The development of a control strategy for this facility to ensure compliance with applicable water quality standards is complicated with numerous other point- and nonpoint-source mining discharges, which have an impact on receiving waters.

Clear Creek/Central City

Including Clear Creek on the 304(l) list was intended to address all of the surface water discharges, primarily from mining operations, which have led to identification of Clear Creek as an NPL site (ranked No. 174 in 1983). EPA has conducted extensive sampling and analysis to characterize the contamination (high metals concentration and toxicity to aquatic life both in Creek water and sediments) and identify contributing discharges. Contaminants of concern include aluminum, arsenic, cadmium, chromium, copper, fluoride, lead, manganese, nickel, silver, zinc, and pH. The greatest toxic effects have been found to occur during seasonal high-flow periods and storms. Active and inactive mine sites in numerous mining sectors with point- and nonpoint-source discharge are the responsible parties.

APPENDIX 1-D

COMMENTS AND RESPONSES

Appendix 1-D: Comments on the Draft Industry Profile and EPA Responses

A draft of the *Industry Profile: Gold* was provided for review and comment to the following: U.S. DOI, Bureau of Mines, the Western Governors' Association, the Interstate Mining Compact Commission, the American Mining Congress (AMC) and various Environmental Interest Groups for their review and comment. Approximately 450 comments were submitted to EPA by the following six reviewers: the Bureau of Mines, American Barrick Resources Corporation, Hecla Mining Company, Homestake Mining Company, Newmont Gold Company, and The Precious Metal Producers. The comments included technical and editorial changes, as well as comments on the scope of the Profile and how it relates to authorities provided under RCRA Subtitle D.

Because several general concerns were raised by a number of commenters, EPA has grouped the comments into two categories. The first includes seven general concerns that were raised by all commenters. These are addressed in the first section below. The second category of comments includes technical comments on this Profile, which were raised by specific reviewers, rather than the group as a whole. These are addressed in the second section below. All other comments, including minor technical and marginal notes, have been incorporated into the revised Profile; EPA believes they have served to improve the document's accuracy and clarity. EPA would like to thank all the agencies, companies, and individuals for their time and effort spent reviewing and preparing comments on the Profile.

General Issues Pertaining to All Profiles

1. Comment: Several commenters objected to the use of hypothetical phrases like "may cause" or "may occur." Their use was characterized as misleading and inappropriate in describing environmental impacts in an Industry Profile of this type.

   Response: It is felt that the descriptions of conditions and impacts that may occur regarding potential effects is appropriate in many cases, since the intent of the relevant sections of the profiles is to describe potential impacts that may occur as a result of extracting and beneficiating ores and minerals. As noted in the responses to related comments below, EPA has extensively revised the sections of the profiles addressing environmental effects. They are now more focussed and direct; they describe, in general terms, a number of specific types of impacts that can occur under particular conditions or in particular environments.

2. Comment: A related issue raised by commenters was that EPA did not balance the profile by describing environmental protection practices currently followed by the mining industry. Instead, the commenters were critical that EPA selected the worst sites to describe, which represent only a small number of mines and even a few clandestine operations.

   Response: It is felt that the Profile (and related site reports) represents current environmental management practices as described in the current literature.

3. Comment: Commenters on each of the profiles were concerned that the sites described in the discussion of environmental effects were under some other regulatory authority (e.g., CERCLA).

   Response: As noted above, the relevant sections of the profiles have been revised extensively. However it is felt that, with proper qualification, sites under other regulatory authorities, including CERCLA, are relevant to any examination of actual or potential environmental effects.

4. Comment: Commenters were concerned that the Profile considered materials other than those considered "wastes" under RCRA.

   Response: Since the profile is intended to identify the potential environmental effects of mining, it was considered appropriate to discuss both wastes and materials that have similar potential to pose risks to human health and the environment.

5. Comment: Many commenters recommended that the mitigating effects of site-specific factors on potential environmental effects be discussed.

   Response: As noted above, the relevant sections of the profiles have been revised including the addition of language that emphasizes the site-specific nature of potential environmental effects.

6. Comment: Many commenters recommended that the effectiveness of State regulatory actions in preventing adverse environmental effects be integrated into any discussion of potential effects.

   Response: The Profile has been amended to reflect the fact that State requirements can substantially reduce or eliminate many adverse environmental effects.

7. Comment: A number of comments were received on the table in each draft profile that cited NIOSH data on the quantities of certain chemicals found on mine property and that included worker exposure limits. Commenters questioned the data's accuracy and relevance.

   Response: The table has been replaced with a simple list of chemicals typically found on sites.

Technical Issues Pertaining to the Gold Profile

8. Comment: The Profile ignores state-led regulatory programs.

   Response: Due to the number of States with programs regulating the mining industry, and the wide variation in those programs, it was decided to address the regulatory programs implemented by two States, Nevada and South Carolina. Nevada was chosen because of the vast majority of current gold mining occurs in that State. South Carolina was selected to reflect mining regulation in a wet climate. A discussion of these is presented in both the draft Profile and this revised document.

10. Comment: The Profile is a 1991 release. The massive expansion of the industry since that time is masked by the use of 1988 data to characterize the industry.

   Response: The most recent publicly available information at the time of the Profile's preparation (late 1990) was used in the draft profile. The draft has been revised to include updated information (as of April 1992) from the Bureau of Mines.

11. Comment: The Profile does not quantify the magnitude of known or potential contamination.

   Response: As noted in the first section above, the primary purpose of the profile is not to catalog or rank environmental effects. The Profile has been revised to clarify its intent.

12. Comment: The use of the word extraction is unclear. Extraction, in the metallurgical sense, refers to a method used to remove the values from the ore; in the Profile it is analogous to mining.

Response: As described in the profile, in 1980 Congress conditionally exempted from RCRA Subtitle C, wastes from the "extraction, beneficiation, and processing of ores and minerals". In this case, the term extraction is analogous to mining.

13. Comment: Too much time is spent on mining and beneficiation techniques that relate to an insignificant portion of the industry. Examples include open cut and block caving methods; flotation, gravity concentration, and *in situ* leaching. This results in speculation about impacts from techniques that are of minimal importance.

    Response: Relevant portions of the profile have been revised substantially in response to this comment. The description of mining methods has been deleted. Text describing by-product gold from base metal operations (flotation) and gravity concentration has been edited significantly. The *in situ* discussion simply references a pilot-scale study, and thus remains largely unchanged in the revised profile.

14. Comment: The profile ignores regulations protecting against acid drainage.

    Response: The Profile has been revised and clarified regarding the discussion of acid drainage. Nevada's regulations governing acid drainage are discussed in the section concerning that State's Water Pollution Control Permits.

15. Comment: Sulfide ores are rarely, if ever, used in heap leaching operations.

    Response: The description of heap leach operations has been extensively revised based on reviewers comments. The text concerning the use of sulfide ores has been modified accordingly.

APPENDIX 1-E

ACRONYM LIST

ACRONYM LIST

AMD	acid mine drainage
AWQC	Ambient Water Quality Criteria
BAT/BPJ	best available technology/best professional judgment
BLM	Bureau of Land Management
BMP	best management practice
BPJ	best professional judgment
CAA	Clean Air Act
CCD	continuous countercurrent decantation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIC	carbon-in-column
CIL	carbon-in-leach
CIP	carbon-in-pulp
CWA	Clean Water Act
DHEC	Department of Health and Environmental Control
dscm	dry standard cubic meter
FLPMA	Federal Land Policy and Management Act
FS	Forest Service
FWS	Fish and Wildlife Service
GA	Groundwater A
GB	Groundwater B
GC	Groundwater C
HDPE	high-density polyethylene
HRS	Hazard Ranking System
ICSs	individual control strategies
IM	Instruction Memorandum
kg	kilogram
lb.	pound
LOEL	Lowest-Observed Effect Level
MCL	Maximum Contaminant Level
mg/l	milligrams per liter
MSHA	Mine Safety and Health Administration
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NMEID	New Mexico Environmental Improvement Division
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
NSPS	New Source Performance Standard
NTIS	National Technical Information Service
oz/t	troy ounces per ton
PME	Precision Metals Extraction. Ltd.
ppm	parts per million
PSD	prevention of significant deterioration

ACRONYM LIST (continued)

RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study
RIP	Resin-in-Pulp
ROD	Record of Decision
SHDG	sediment-hosted disseminated gold
SIP	State Implementation Plan
TSCA	Toxic Substance Control Act
TSS	total suspended solids
USC	U.S. Code
U.S. DOI	U.S. Department of the Interior
U.S. EPA	U.S. Environmental Protection Agency
U.S. GS	United States Geological Survey
VLDPE	very low-density polyethylene
WAD	weak acid dissociable

MINE SITE VISIT:

BREWER GOLD COMPANY

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street S.W.
Washington, D.C. 20460

2.0 SITE VISIT REPORT: BREWER MINE

2.1 INTRODUCTION

2.1.1 Background

The U.S. Environmental Protection Agency (EPA) is assisting states to improve their mining programs. As part of this ongoing effort, EPA is gathering data related to waste generation and management practices by conducting site visits to mine sites. As one of several site visits, EPA visited Brewer Gold Company's facility near Jefferson, South Carolina on September 24, 1991.

Sites to be visited were selected to represent both an array of mining industry sectors and different regional geographies. All sites visits have been conducted pursuant to RCRA Sections 3001 and 3007 information collection authorities. When sites have been on Federal land, EPA has invited representatives of the land management agencies (Forest Service and/or Bureau of Land Management) to participate. State agency representatives and EPA regional personnel have also been invited to participate in each site visit.

For each site, EPA has collected information using a three-step approach: (1) contacting the facility by telephone to obtain initial information, (2) contacting state regulatory agencies by telephone to get further information, and (3) conducting the actual site visit. Information collected prior to the site visit is then reviewed and confirmed at the site.

In preparing this report, EPA collected information from a variety of sources, including the Brewer Gold Company, the South Carolina Department of Health and Environmental Control (DHEC), the South Carolina Land Resources Commission (LRC), information from telephone conversations with Brewer Gold Company and with DHEC and LRC, and from other published sources. The following individuals participated in the Brewer Gold Company site visit on September 24, 1991:

<u>Brewer Gold Company</u>

Ken Barnes, Mine Maintenance Superintendent (803) 658-3039
Gary Froemming, Mine Supervisor (803) 658-3039
R.M. Mattson, General Manager (803) 658-3039
Jaye Pickards, Plant Supervisor (803) 658-3039
Scott Wanstedt, Environmental Engineer (803) 658-3039
Mark Zwaschka, Geologist (803) 658-3039

<u>S.C. Land Resources Commission, Division of Mining and Reclamation</u>

Craig Kennedy, Assistant Director
(803) 734-9100
Pat Walker, Director (803) 734-9100

<u>S.C. Department of Health and Environmental Control</u>

Ed E. Hart, Facility Evaluator (803) 662-3522
Marion R. Rembert, District Director
(803) 662-3522

<u>U.S. Environmental Protection Agency</u>

Van Housman, Chemical Engineer
(703) 308-8419

<u>Science Applications International Corporation</u>

Jack Mozingo, Environmental Scientist
(703) 734-2513
Jonathan M. Passe, Regulatory Analyst
(703) 821-4831

Participants in the site visit were provided an opportunity to comment on a draft of this report. Comments were submitted by the Brewer Gold Company and the State of South Carolina. Brewer Gold Company comments are presented in Appendix 2-A; State Comments are presented in Appendices 2-B and 2-C. EPA's response to the Brewer Company's and State comments are presented in Appendices 2-D and 2-E.

2.1.2 General Facility Description

The Brewer Gold Mine is located in Chesterfield County, South Carolina, approximately 1.5 miles west of the town of Jefferson (see Figure 2-1

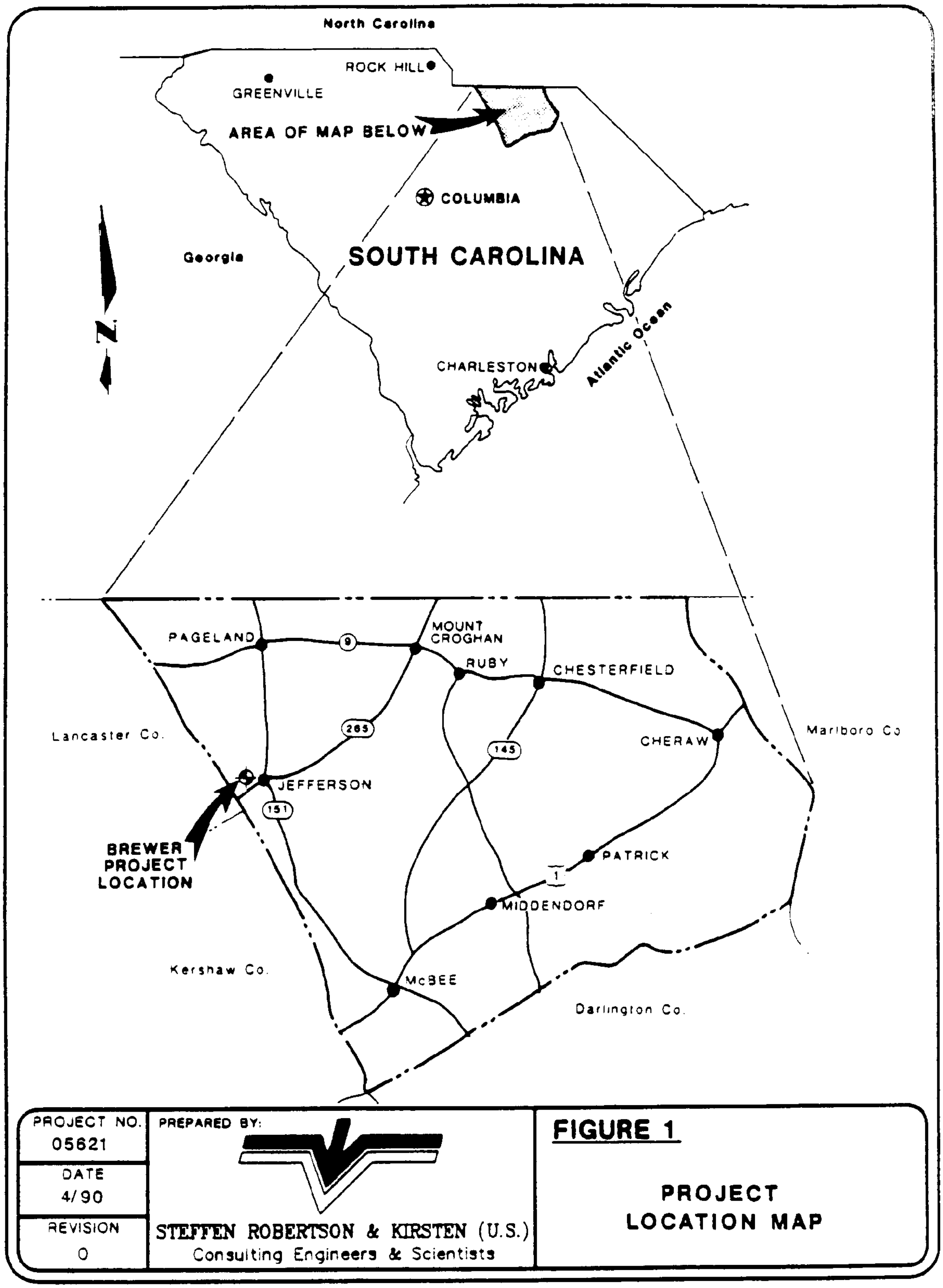


Figure 2-1. Location of Brewer Gold Mine

(Source: Figure 1 in Brewer Gold Company, 1990b)

). The mine site is situated on a ridge between Lynches River on the west and Little Fork Creek (a tributary to Lynches River) to the east. Highway 265 bounds the property on the southern side (Brewer Gold Company Description). The predominant land uses within four miles of the Brewer site include urban (the town of Jefferson), farming, commercial/light industry (poultry), and undeveloped forest area. There is no zoning in Chesterfield County.

The Brewer Gold facility is sited on privately owned lands. The total area disturbed by the facility is estimated to be slightly over 200 acres, with a reserve (currently inactive) of an additional 20 acres. Ore is mined from the Brewer Pit using open pit methods, although the current pit intersects old underground workings. Ore is hauled to on-site crushers, agglomerated, and conveyed to a heap leach pad. The Brewer Gold facility uses a cyanide solution to recover gold from ore that has been crushed and placed on leach pads. Leachate collected from the leach heaps is carbon stripped and gold is then electrowon, electroplated, and melted into dore bars in the facility's crucible furnace.

Gold was first mined at the Brewer site in the late 1820s; by the late 1800s, a substantial operation, including a 40-stamp mill, was underway at the property. Operations ceased in 1941, and significant exploration activity did not restart until the late 1970s, when gold prices sparked renewed interest in the area. The corporate predecessor to Westmont, which was Brewer Gold Company's former parent company, commenced exploration in 1983 and, during the period 1984 through 1986, carried out exploration and engineering feasibility studies, leading to a project go-ahead decision in January 1987. The construction period lasted six months, and the first gold was poured in early August 1987 (Brewer Gold Company, undated).

Between June 1987 and the end of March 1991, Brewer Gold Company removed from its pit a total of 9.2 million tons[1] of combined ore and waste, of which 3.8 million tons were ore that was crushed and beneficiated. Cumulative gold production from the Brewer site prior to the 1980s is estimated at 22,000 troy ounces. Since start-up in 1987, through March 1991, Brewer Gold Company has produced 118,087 ounces. Thus, the estimated total production to date from the Brewer site is estimated to be in excess of 140,000 ounces. Small amounts of silver are also recovered at the facility (Brewer Gold Company, undated).

Production at the Brewer mine was suspended following a cyanide spill caused by a dam failure on October 28, 1990. Production resumed on June 20, 1991. Projected 1991 production was 23,000 troy ounces of gold; projected 1992 production was 38,000 troy ounces. The total life of the mine was originally estimated to be approximately 5 years, with 2 to 2.5 years of known, minable reserves remaining at the time of the site visit. Additional exploration on-site and in nearby areas may extend the life of the mine (EPA, 1991).

2.1.3 Environmental Setting

2.1.3.1 Surface Water

[1]In this report, "tons" refers to short tons (2,000 pounds). "Ounces" refers to troy ounces (1 troy ounce is equal to 0.06857 pound).

The immediate discharge point for the Brewer Gold Company facility is Little Fork Creek. The Creek is designated by the State of South Carolina as a Class B water (i.e., suitable for secondary contact recreation, as a drinking water supply after conventional treatment, and for fishing, agricultural, and industrial uses). The principle use is for cattle watering. The Creek has no significant floodplain since it occupies a relatively narrow valley. Little Fork Creek has several smaller tributaries, including a stream that receives discharge from an adit from the historic workings and which drains the present pit. Little Fork Creek discharges to Fork Creek about two miles downstream from the Brewer site; Fork Creek enters Lynches River about one-half mile below that.

Average monthly stream flows in Little Fork Creek range from 3.9 cubic feet per second (cfs), or 1,743 gallons per minute (gpm), in October to 34.4 cfs (15,456 gpm) in March. In Fork Creek, average monthly stream flow ranges from 6.3 cfs in October to 55.8 cfs in March (Brewer Gold Company, 1991b).

A water quality study was conducted on Little Fork Creek as part of an overall Ecological Assessment performed by a Brewer contractor for the initial mining permit application. The study found pH values in the Creek and its tributaries ranging from 6.49 to 7.35. At sampling point LCF-2A, upstream of Brewer's permitted discharge point but affected by discharge from an adit from the historic mine workings, pH was measured at 3.55. Samples from this location also indicated elevated sulfate levels due to the presence of oxidized pyrite. Concentrations of barium, cadmium, chromium, lead, mercury, selenium, silver, and zinc were at or below detection limits for all creek water samples. Arsenic concentrations were quantifiable, but all were well below EPA's 0.05 mg/L drinking water standard. Copper levels at the mine adit discharge were recorded at 0.26 mg/L and were below the detection limit at all other sampling stations. Iron concentrations at all sampling points in the Creek ranged from 2.10 mg/L to 2.99 mg/L. All measured tributaries, however, exhibited lower iron levels (Environmental and Chemical Services, Inc., 1987).

Subsequent to a release of cyanide solution into the Creek in October 1990, Brewer commissioned a study of macroinvertebrates and fish communities in Little Fork and Fork Creeks (the facility's current NPDES permit requires macroinvertebrate studies twice a year; the permit was being revised at the time of the site visit and the draft permit would require macroinvertebrate studies three times per year). This particular study, conducted in March 1991, indicated that communities downstream of the cyanide spill continued to show signs of impact several months after the spill event. Specifically, taxa richness and number of individuals were reduced downstream of the release point. The study also noted that macroinvertebrate and fish populations in Lynches River had rebounded since the spill incident and that further improvement was expected (Shealy Environmental Services, Inc., 1991).

2.1.3.2 Geology

The Brewer deposit is a crudely formed, crescent-shaped breccia body approximately 1,100 feet long by an average of 300 feet wide. Ore grade material is encountered to depths of over 400 feet. The grade of the deposit averages 0.040 ounces of gold per ton of ore (Brewer Gold Company, undated).

The Brewer mine property lies on the contact between the Piedmont and Coastal Plains geomorphic provinces. The complex geology of the Brewer mine consists of cross-cutting breccia pipes occurring near the contact of the Persimmon Fork formation and the overlying Richtex argillites of the Piedmont. The Brewer breccia is a heterolithic breccia believed to be of multi-episodic hydrothermal origin. Subsequent faulting and folding of this entire rock group has formed a complex ore body (Brewer Gold Company, undated; Scheetz et al., 1991).

The dominant minerals in the breccia are quartz, pyrite, enargite, and topaz. Accessory minerals observed are cassiterite, covellite, bornite, tennantite, bismuth, sphalerite, galena, cinnabar, and gold. The elemental signature for the breccia has been reported to be iron, manganese, copper, molybdenum, arsenic, silver, magnesium, gold, and mercury. The primary gold mineralization is confined to a composite hydrothermal breccia body in which several periods of brecciation and hydrothermal fluid migration can be documented. The gold is thought to have been deposited in the breccia by hydrothermal action (Brewer Gold Company, undated; Scheetz et al., 1991).

A local fractured system is present in the Brewer area. The area is classified by the U.S. Geological Survey as being between a 2 and 3 seismic zone. These zones are based on the distribution of historical, damaging earthquakes, their intensities, evidence of strain release, and distributions of geological structures related to earthquake activity.

2.1.3.3 Hydrogeology

The depth to the uppermost aquifer (unnamed) below the Brewer facility ranges from 10 to over 100 feet. Depth to the aquifer is controlled by local topography. The aquifer is estimated to be thicker than 100 feet. The aquifer is classified as a Class II aquifer by EPA (current and potential source of drinking water and having other beneficial uses) and as a Class GB aquifer (similar to EPA's Class II designation) by the State of South Carolina. This aquifer supplies water to the Brewer facility through two main wells that reached water at about 50 feet and are about 250 to 300 feet deep. Other uses of the aquifer were not known. Interconnections between this aquifer and others (e.g., alluvial aquifers) were not described.

Private wells in the area (for agricultural and commercial/industrial usage) use shallow alluvial aquifers associated with surface water bodies. The facility is located between 0.5 and 1 mile from the nearest drinking water well and over 4 miles from the nearest public water system (which was said to probably be in Pageland, S.C., upstream of the site). Nearby drinking water wells were sampled in 1990-1991 and the water was found to be within State standards. The Brewer facility itself uses bottled water for drinking water.

2.2 FACILITY OPERATIONS

The Brewer site, which is named for the original owner of the property, has had a long history of intermittent mining operations, some of which were for minerals other than gold. It has been reported that a miner named Fudge first worked the site, presumably for iron, before the Revolutionary War. Gold was first discovered at the site in 1827 or 1828. Gold was first produced at Brewer in 1828 from placer deposits using gold pans, sluice boxes, and other similar devices that used water and gravity to separate gold from the ore (Brewer Gold Company, undated).

Hydraulic mining began at the site in 1877. In this process, jets of water under high pressure washed loosely consolidated material into sluice boxes where gold was recovered. A five-stamp mill was built in 1885 and enlarged to a 40-stamp mill in 1888. In 1887, an adit, the present drainage tunnel from the bottom of the Brewer pit, was driven westward for approximately 1,000 feet into the hillside under the main ore zone. The mine was opened from below by a raise driven up through the ore body, connecting it to the pit above. It was these workings that were enlarged to create the old Brewer pit. A narrow gauge track was laid in the tunnel and ore was hauled to a mill by a small locomotive. The 40-stamp mill was located on Little Fork Creek downstream from the lower portal of the tunnel (Brewer Gold Company, undated).

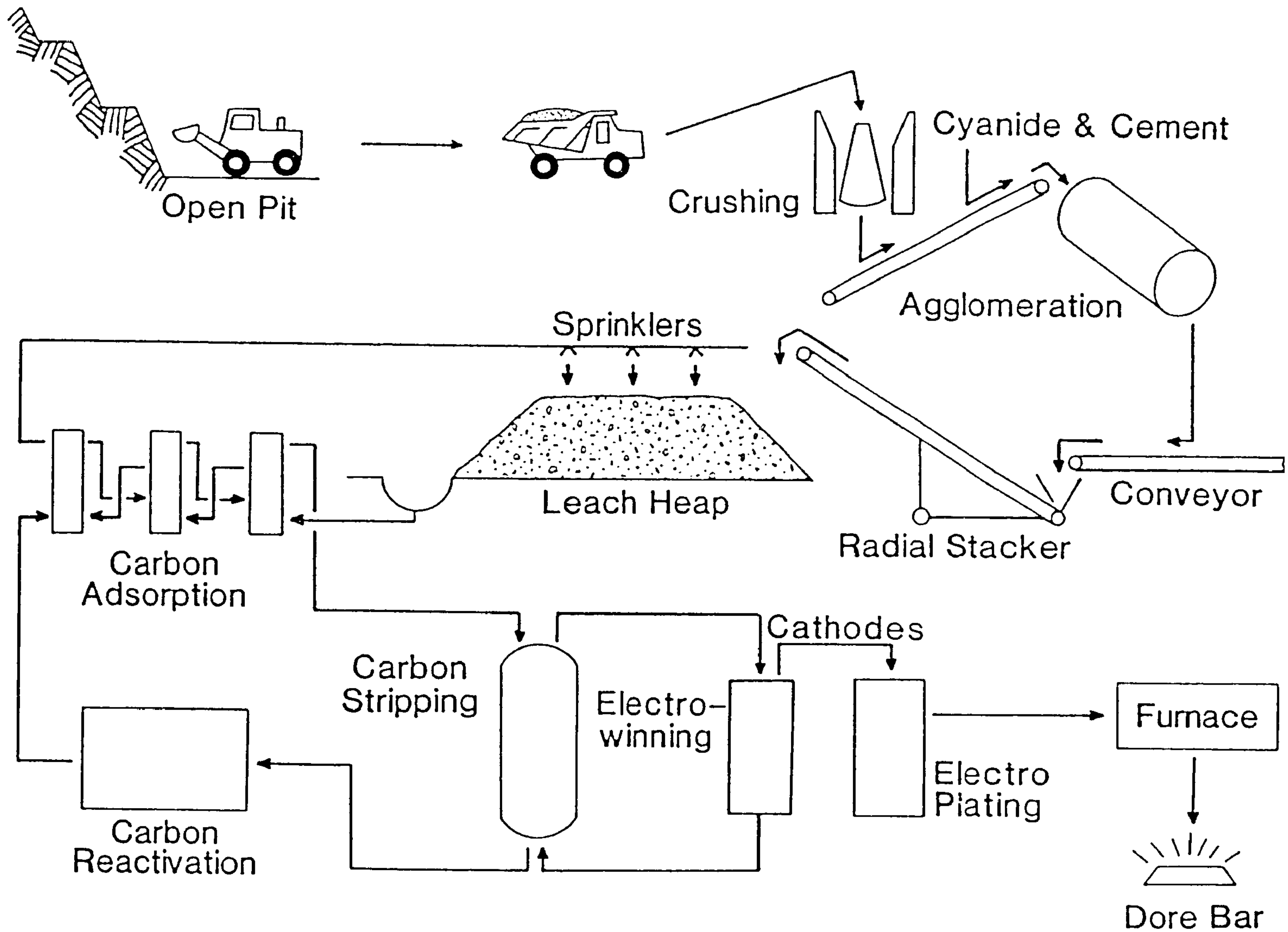
Nicor Mineral Ventures and Gold Resources, Inc. entered into a joint venture in September 1983 to conduct exploration and a possible development program for the Brewer gold deposit. Exploration and bulk sampling was conducted between 1984 and 1986, when the feasibility study for a modern project was completed. Also in 1986, Costain Holdings (or a subsidiary, Costain Minerals) acquired Nicor Mineral Ventures and formed a new company known as Westmont Mining, Inc. In March 1987, Westmont Mining began breaking ground for the processing facilities of the Brewer Gold project. The Brewer Gold Company was formed as a subsidiary of Westmont in July 1987 to operate the newly constructed facilities. (In 1991, Brewer Gold became a direct subsidiary of Costain when Westmont was sold to Cambior USA.) Pre-production stripping began in June, ore crushing in July, and the first gold was produced by the Brewer Gold Company in August 1987. Brewer Gold currently employs approximately 104 people in its mine, crushing plant, carbon adsorption plant, on-site laboratory, and administrative office (Brewer Gold Company, undated).

2.2.1 Mining Operations

Mining operations at the Brewer pit remove approximately 5,500 tons of ore per day (tpd) and an additional 6,500 tpd of waste rock for a total production of 12,000 tpd. (Brewer Gold Company, undated). Blastholes with a 6.5-inch-diameter are drilled using a crawler drill (with air compressor) to a depth of 22 feet on a 14-foot by 14-foot pattern. Drill cores or cuttings are assayed to determine the gold content (i.e., whether material is to be leached or considered low-grade ore or waste rock). The holes are filled with ammonium nitrate fuel oil (ANFO) and the rock is blasted. A six cubic yard hydraulic shovel or front-end loader then loads the broken rock into 35-ton haul trucks, which carry the material either to the waste rock and low-grade ore pile or to the 60,000- to 100,000-ton capacity ore surge pile near the crushing circuit (Brewer Gold Company, undated). The facility's unlined waste rock dump covers a 17 acre area and contains 4.5 million tons of waste rock (waste rock cutoff = 0.017 ounces of gold per ton) as well as 550,000 tons of low-grade ore (i.e., material with from 0.01 to 0.017 ounces of gold per ton). One section of the pile contains 20,000 to 30,000 tons of high sulfide material, which may contain gold values higher than the cutoff grades.

2.2.2 Beneficiation Operations

Ore is fed by a 7.5-cubic-yard front-end loader from the run-of-mine ore stockpile onto a vibrating feeder grizzly (see process flowsheet in Figure 2-2


Open Pit
Crushing
Cyanide & Cement
Agglomeration
Sprinklers
Leach Heap
Radial Stacker
Conveyor
Carbon Adsorption
Carbon Stripping
Cathodes
Electro-winning
Electro Plating
Furnace
Carbon Reactivation
Dore Bar

and site map in Figure 2-3). Oversize from this grizzly feeds a 30-inch by 42-inch primary jaw crusher,

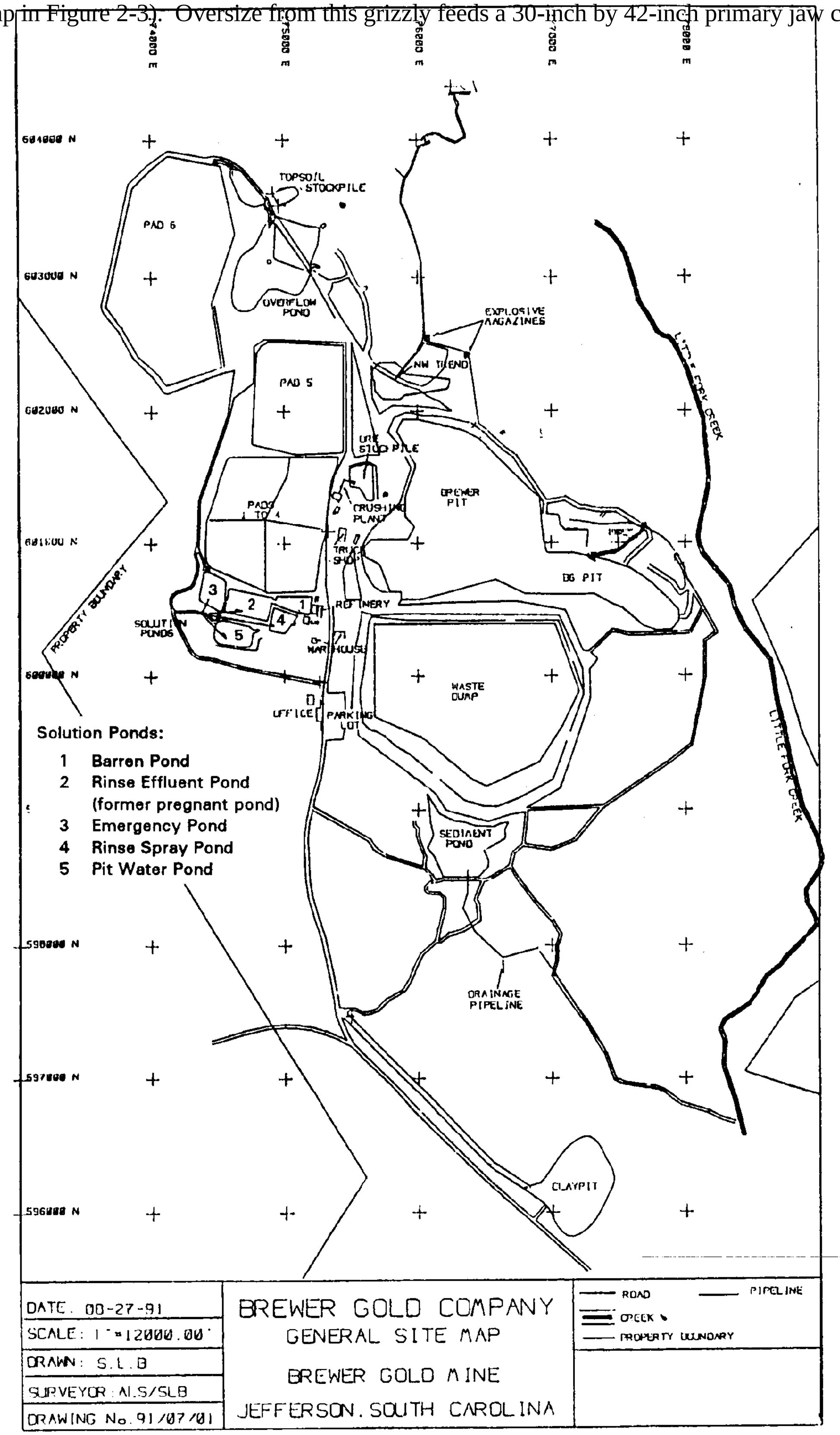


Figure 2-3. Location of Facility Operations, Brewer Gold Mine

which discharges onto a belt feeding a double-neck screen. Material less than one inch in diameter falls through the screen and oversize material enters a secondary cone crusher where it is crushed to less than 1 inch. Ore from the secondary crusher is screened and placed on a 10,000-ton surge pile, from which it is later reclaimed and fed into the agglomerator. As this material is conveyed to the agglomerator, it passes over a weightometer and under a cement silo (capacity = 125,000 pounds), where approximately six pounds of cement per ton of ore is added (the cement serves to bind fine materials to enhance agglomeration). The ore is then fed into a rotating agglomerator drum (10-foot-diameter by 21-foot-long), where barren dilute sodium cyanide solution, a polymer agglomerating aid, and calcium cyanide are added to the ore (rates per ton of ore were not obtained). The agglomerator mixes the material such that the fine particles are either cemented into coarser particles or are rolled into porous balls. When stacked into heaps, this enhances percolation of leaching solutions (Brewer Gold Company, undated).

Agglomerated ore is transferred to the Pad 6 heap via a series of conveyor belts and an ore stacker. The heap is stacked to approximately 35 feet in height using a radial stacker. This heap covers about 1,100,000 square feet and has an ultimate capacity of about 2,400,000 tons of ore. Dilute cyanide solution (200 ppm) is pumped from a double-lined Barren Pond (7-feet deep) located next to the carbon adsorption plant to sprinklers located on top of the Pad 6 heap. The solution is generally applied at a rate of 200 to 250 gpm. This barren solution, containing little or no gold, percolates through the ore heaps, dissolving gold particles with which it comes in contact. The resulting "pregnant solution" (i.e., loaded with gold) is conveyed along the impervious primary liner (60-mil HDPE, which is underlain by twelve inches of compacted clay) and in lined ditches into a sump on one corner of the pad. From the sump, it is pumped to the carbon plant (see site map in Figure 2-3) (Brewer Gold Company, undated). Excess solution (e.g., from rain infiltration) flows through lined ditches to the Pad 6 Overflow Pond, from which it can be pumped to the carbon plant. Leaching has been completed on pads 1 through 5 and 5A and ore is currently being rinsed, as described in section 2.3.3.

In addition to cyanide leaching on Pad 6, Brewer has placed a test pile of high-sulfide ore on a section of the pad. This material is being leached with water, which acidifies and removes copper as it percolates through the ore. The test is intended to determine whether copper recovery is feasible and/or if the copper content of the sulfide ore can be reduced to the point where gold recovery via cyanide leaching is feasible. According to Brewer representatives, copper concentrations had been reduced from 4,000 to 400 ppm (the date when leaching began was not determined).

The carbon adsorption circuit is a closed-loop countercurrent flow system consisting of five gravity flow carbon columns. Each column is 6-foot-diameter by 8-foot-high, has a capacity of just over one ton of carbon (roasted coconut shells), and is designed to a handle a nominal flow of 600 gallons of solution per minute. Carbon particles are advanced through the series as gold (and other metals) is adsorbed on the surface of the activated carbon. Pregnant solution is pumped from the sump on Pad 6 (and/or from the pad 6 overflow pond) via pipeline to the carbon circuit. After the solution has passed through all five stages (columns) of carbon, it is discharged to the double-lined Barren Pond (which is immediately below the circuit), refortified with cyanide, and pumped back to Pad 6 (Brewer Gold Company, undated). Excess barren solution may be treated with hydrogen peroxide and calcium hypochlorite (for cyanide) and flocculants (for metals) and discharged to the Sediment Pond or used as rinsewater.

When the carbon becomes laden with gold values (up to approximately 100 pounds of gold per ton, or 18 to 24 hours of adsorption time), it is pumped out of the column system and loaded into a stripping vessel. In the stripping process, adsorption is reversed using a three to four percent cyanide/strong caustic (pH = 13.5) electrolyte solution and the gold is electrowon onto steel wool cathodes (Brewer Gold Company, undated).

Typically, Brewer maintains a 4 to 1 ratio of cyanide to copper in the electrolyte solution to improve the dore quality by binding the copper and cyanide. The electrolyte solution is changed weekly and discharged to the facility's Barren Pond (volume was not determined). This solution typically contains 4,000 ppm copper. Sludges are scraped out of the electrowinning cells monthly and sent off-site to recover copper and silver values.

The stripped carbon is first washed with nitric acid to remove organic material and silica that interfere with the reactivation process. The wash from this process is discharged to the Barren Pond and neutralized by the high-pH barren solution (volumes of discharge from the acid wash were not obtained). Carbon regeneration involves treatment with a hot caustic (one percent)/weak cyanide (0.25 - 0.5 percent) solution and heating to 270° F. Regenerated carbon particles are placed back into the carbon adsorption circuit. An average of four percent of the carbon is lost as fines during reactivation. This material is sold to an out-of-state firm that recovers additional gold values.

The gold-loaded steel wool is then transferred to an electrorefining cell, where gold is removed from the steel wool by replating onto stainless steel cathode plates. Gold is then scraped from these plates and melted in a natural gas-fired furnace at a temperature of approximately 2,000° F. to produce gold dore bars which are shipped to refiners. The dore bars are composed of approximately 80 to 84 percent gold, copper, silver, and other trace elements. On average, the Brewer Gold Company facility produces 100 troy ounces of dore gold per day.

Furnace slag (about one ton per year) and graphite crucibles from the facility furnace also are sold to an out-of-state firm that recovers additional gold values from the sources. In 1990, approximately 200 troy ounces of gold were recovered from these sources and from the electrowinning sludges and carbon fines discussed above.

2.2.3 Chemical Usage

Table 2-1 summarizes Brewer Gold Company's chemical purchases from January 1, 1991 through September 25, 1991. As noted above, from the beginning of 1991 (actually, from October 1990) through June 20, the facility had suspended the addition of new cyanide to leaching solutions, although leachate (and rinsate) continued to be recirculated through the system.

Table 2-1. Brewer Gold Company Chemical Purchases, January - September 1991

Chemical	Quantity
Caustic soda	45,000 pounds
Hydrated lime	180,880 gallons
Nitric acid	1,540 gallons
Calcium cyanide	476,000 pounds
Sodium cyanide	88,000 pounds
Hydrogen peroxide (50%)	784,000 pounds
Drew Chargepak 5 (floc)	2,090 gallons
Drew MP-3r Amersep. (floc)	1,980 gallons
Exxon Sureflo 7647 (antiscalant)	5,000 gallons

Source: Brewer Gold Company, 1991g

2.3 MATERIALS AND WASTE MANAGEMENT

For purposes of this discussion, materials management practices at the Brewer Gold Company mine are divided into process and waste management units. Process units are those that contain materials that are not considered wastes until after facility closure. Examples of process units (and process materials) are heap leach pads (and spent ore) and the open pit (and mine water in the pit during operation). Waste units are those that contain materials that will undergo no further beneficiation. Examples of these include waste rock piles and wastewater holding ponds.

The following section describes waste and material management at the Brewer Gold Company site. Also included is a discussion of current closure and reclamation plans for each mine component. Actual closure practices and requirements will be determined by the State as the end of the mine's active life approaches.

2.3.1 Mine Pit and Water

The total disturbance of the Brewer pit is approximately 33 acres. From the highest point of 580 feet above sea level, the pit has now reached an elevation of about 400 feet. In addition, Brewer was considering (at the time of the site visit) mining an off-site satellite pit beginning in February 1992, pending the appropriate permits from DHEC and the Land Resources Commission. Ore will be trucked to the present site for beneficiation and processing (the pit is located in adjacent Lancaster County near the town of Kershaw). Upon cessation of operations at the Brewer site, pit dewatering will cease and the water table will be allowed to return to its near-natural level, which will form a small lake in the lower extremities of the pit. The natural water table is approximately the level to which mining has currently reached, so continual dewatering has not been necessary to date. According to Brewer representatives, the pit will be excavated to some additional depth (estimated to be about 100 feet, to the 300 foot level), so there will be a "lake" in the pit after closure. As more sulfide-bearing minerals are exposed to an oxidizing environment as the pit deepens, acid generation may occur.

Upon closure, reclamation of the pit will involve stabilizing the slopes by dozing and blasting areas determined to be unstable (Brewer Gold Company, 1990b). According to the Land Resources Commission, sloping to a 3H:1V gradient will be required in the upper portions of the pit wall where saprolite and soil exist. After sloping is completed, vegetation will be established. As noted, the pit will contain water upon closure. Upon final reclamation, this water will be required to meet applicable water quality standards for lakes, as promulgated by DHEC. Due to the acid generation potential in the lower portions of the Brewer pit, Brewer has proposed that process solutions may be diverted directly to the pit. This would decrease the time necessary to fill the pit with water, which would minimize the time that sulfide minerals in the pit would be exposed to an oxidizing environment. In addition, because the process solution will have an elevated pH, it could act as a buffering agent for any acid that may have formed in the pit.

Pit water includes any ground water infiltrating into the pit, precipitation directly entering the pit, and any site runoff that flows into the pit. These waters currently drain out of the pit through an old adit previously used in underground mining operations at the site, which also drains underground workings. A.S.C.I. (1990) referred to pH values of 2 and relatively high copper concentrations in adit discharges, but further information on adit or pit water quality was not available.

The facility's NPDES permit, as modified in late 1990, requires the installation and use of a treatment system for pit water prior to its discharge via internal outfall to the Sediment Pond (see discussion of Construction Permits 16,727 and 17,170 in section 2.4 below). With this treatment system, pit water will be pumped from the pit to a double-lined 3.5 million gallon pond near the carbon circuit and treated with lime and flocculants to adjust pH and reduce metals (particularly copper). From there, water will be used to supply the rinse circuit or discharged to the Sediment Pond prior to discharge via existing NPDES outfall 001. Brewer estimates that discharge to the Sediment Pond will average between 75 and 100 gpm. Brewer representatives indicated during the site visit that the treatment system had been completed and was awaiting State approval before being placed in service; according to DHEC, the system obtained an operating permit on February 14, 1992. Brewer representatives also indicated that the old adit, through which pit water was previously discharged, would be plugged at the upstream end (i.e., at the pit). Discussions between Brewer and the State were ongoing concerning the remaining ground-water drainage from the old adit once the upstream end is plugged.

2.3.2 Waste Rock Pile

The stripping ratio of the Brewer Mine is approximately 1.2:1. To date, about 4.5 million tons of waste rock have been disposed in an unlined multi-lift pile covering an area of 17 acres. Site preparation for the waste pile consisted of compacting native soil. Runoff from the pile, which is located immediately south of and adjacent to the Brewer pit, drains into the facility's Sediment Pond and the mine pit.

Waste rock (cutoff = 0.017 ounces of gold per ton of rock) at the Brewer facility is typically alumina/silica rock containing quartz and one to three percent pyrite. Low-grade ore (0.01 to 0.017 ounces of gold per ton of rock) is placed in a designated area of the pile. There are currently 550,000 tons of low-grade set-aside ore in the waste rock pile. In addition, high sulfide material is segregated in a discrete section of the waste rock pile for potential future use or disposal (oxide and mixed materials have very little buffering capacity, so mixed disposal was determined to have little benefit in mitigating acid potential [A.S.C.I., 1990]). To date, only 20,000 to 30,000 tons of high sulfide material have been removed from the mine, although as the pit extends downward, the percentage of sulfide material may increase. Drainage from this area of the pile flows into the Brewer pit.

Samples of waste rock taken in 1988 (no information was available on locations or types of samples) showed total sulfur values ranging from less than one percent to over 17 percent. Acid generation potential of waste rock, based on humidity cell testing, is described as "moderate" (no definition of "moderate" was provided) (A.S.C.I., 1990).

As described in section 2.4.1.1, Brewer monitors ground water in three wells near the waste rock pile and Sediment Pond.

Closure activities are expected to require special grading and site preparation. Specifically, to minimize erosive forces of runoff, grading of the top portion of the waste will be towards the northeast and away from the side slopes, thus limiting overland flows down the slopes to incidental precipitation. Current plans are to direct the runoff into the mine pit for additional sediment control. Other reclamation may include the installation of an impermeable cap for acid control and a layer of non-toxic material and/or topsoil to support vegetation and maintain the integrity of the cap (Brewer Gold Company, 1990b).

Closure activities for the high sulfide section of the pile are expected to involve grading and in-place encapsulation with either a compacted clay layer or a synthetic layer to restrict water movement through the material to limit oxidation and transport of acid. Other acid control technologies, such as active treatment of sulfide materials with lime or the addition of bacterial inhibitors, are also being evaluated. (Brewer Gold Company, 1990b)

The Land Resources Commission emphasizes that the present closure plan (Brewer Gold Company, 1990b) is preliminary and was based on partial data in order to develop conceptual plans for closure. A final closure plan will be required, with more information derived from operational data and additional test data, and will specify proper closure requirements for the waste rock dump, leach pad(s), acid generation potential, pit water chemistry, and plant process facilities.

2.3.3 Leach Pads and Spent Ore

There are seven heap leach pads, which cover about 53 acres, at the Brewer site. Currently, only Pad 6 is being actively leached. Pads 1 through 5 and 5A are being rinsed to reduce cyanide levels and pH. Pads 1 through 5 and 5A contain about 2.8 million tons of spent ore.

Pads 1 through 4 are contiguous, each measuring approximately 170,000 square feet. They were constructed with a 40-mil HDPE primary liner over 12 inches of compacted "silty clayey colluvial material;" there is no leak detection system between or below the liners (Steffen Robertson & Kirsten, undated). These pads were part of the original facility construction. Pad 5, constructed in 1988, was initially intended to be an on-off leach pad of 425,000 square feet with an asphalt base; the use of asphalt was intended to minimize the risk of liner degradation during ore movement. The on-off plan was subsequently abandoned (in 1989) and spent ore remains on the pad during rinsing until its ultimate fate at closure is determined. Pad 5 asphalt has a permeability of $2x10^{-6}$ to $1x10^{-7}$, with a $1x10^{-9}$ rubber membrane in the center of the asphalt. The asphalt overlies 12 inches of crushed stone with a fabric filter and a french drain leak detection system around the downgradient perimeter. There also is a leak detection sump. Pad 5A covers a 60,000 square foot area between Pads 1-4 and Pad 5. Except for the portions of Pad 5A located on the asphalt apron of Pad 5, Pad 5A has a 60-mil HDPE liner over compacted clay; only the asphalt portion of Pad 5A has leak detection capability.

Active cyanide leaching was concluded on Pads 1 through 5 and 5A prior to 1990, and full-scale rinsing began in mid-1990. Although South Carolina law does not require rinsing to a specific cyanide concentration (levels must be "to the satisfaction of the State"), the State requires Brewer to rinse the spent ore on the heap leach pads until cyanide and metal concentrations in rinsate reach acceptable levels (either NPDES water quality standards or drinking water standards, depending on the ultimate fate of the spent ore). According to DHEC, when the free cyanide concentration reaches 0.2 ppm, it will trigger monthly rinsate testing for NPDES parameters and for free, total, and weak acid dissociable cyanide. The State considers that this will demonstrate that adequate rinsing has been conducted as well as aid in determining specific closure methods for the spent heaps. According to the Land Resources Commission, heaps closed and reclaimed in-place (as these may be, since the decision had not been made) will have to demonstrate that runoff will not adversely affect aquatic life in neighboring streams.

Brewer Gold Company received a permit to modify its calcium hypochlorite treatment system by adding hydrogen peroxide treatment in May 1990 (DHEC, 1990d). The system is intended to treat rinsate as well as other cyanide-bearing waters prior to re-use in rinsing or discharge to the Sediment Pond. (The extent to which the system had been used for rinsate by early 1991 was not clear. Brewer's "Status Report and Schedule for Rinsing" [Brewer Gold Company, 1991e] indicates at one point that rinsing through June 1991 involved "no treatment whatsoever." At another point, the report indicates that the hydrogen peroxide solution treatment system "has been successfully utilized for the production of clean rinse solution since its installation.") In any event, the treatment system previously involved the use of calcium hypochlorite for cyanide destruction. The new system involves the addition of hydrogen peroxide to the rinse solution. A flocculent may also be added to the treated solution prior to settling (Steffen Robertson and Kirsten, 1990). Rinsate is generally applied to the heaps at 600 gpm. Brewer estimated in March 1991 that rinsing of Pads 1 through 5 and 5A would take an additional 661 days for cyanide concentrations to reach the levels required; as of March 1991, cyanide concentrations had decreased from about 300 ppm to 10 ppm or less (Brewer Gold Company, 1991e).

Rinsate from Pad 5 collects in a sump on the pad and is either pumped to the treatment plant or re-applied without treatment. Rinsate from pads 1 through 4 collects in a common sump or drains to a double-lined rinse effluent pond (the former pregnant pond for pads 1 through 4). After peroxide treatment (and flocculation), the solution is stored in a double-lined rinse settling/reclaim pond, from which it is recirculated to the pads under rinse or used as cyanide leachate makeup and applied to Pad 6. Excess rinsate is treated and discharged to the Sediment Pond. (Steffen Robertson and Kirsten, 1990; EPA, 1991)

Pad 6 covers an area of between 1 and 1.2 million square feet and has an ultimate ore capacity of about 2.4 million tons of agglomerated ore. Most of Pad 6 now contains a single 35-foot lift of ore, and only a small portion of liner remained uncovered at the time of the site visit (a larger area of liner was exposed during heavy rains in October 1990, which contributed to water management problems at that time). A second 35-foot lift was expected to be added to Pad 6 beginning in late 1991 (EPA, 1991). Pregnant solution is collected in a sump at one corner of Pad 6 before being pumped to the carbon adsorption circuit. Excess solution from infiltration of rainfall and runoff drain via lined ditches that surround the heap to the Pad 6 overflow pond (see section 2.3.5 below) prior to being pumped to the carbon circuit.

As described in section 2.4.1.1, Brewer monitors ground water in four wells near Pad 6. Results of monitoring are presented in that section.

When cyanide leaching is completed, Pad 6 also will be rinsed to reduce cyanide and metal concentrations. Brewer estimates that one year of rinsing at 1,600 gpm, beginning in 1993 or 1994, will be sufficient to achieve cyanide levels below 0.2 ppm (Brewer Gold Company, 1991e). No information was available on the ultimate fate of the high sulfide ore being water-leached on a small area of Pad 6 at the time of the site visit.

Samples of spent ore were tested for Extraction Procedure (EP) Toxicity and were found not to demonstrate this hazardous characteristic (sources and numbers of samples, dates, and other information on this sampling were not available). Tests in 1988 for acid production potential/acid neutralization potential (in tons of $CaCO_3$/kTon) indicated that the "acid generation potential is high." It also was not known if lime that is added to ore for pH control will prevent long-term acid generation (A.S.C.I., 1990).

Once rinsing is completed on the various pads, Brewer will have several options for managing the spent ore, depending on the quality of rinsate and solid sample tests. In general, the option ultimately selected by Brewer and approved by the State will depend on the success of rinsing in reducing pH and concentrations of cyanide and copper and other metals and on the quality of rinsate. Options include:

- If concentrations in rinsate and solid samples meet NPDES water quality-based limits, spent ore may be off-loaded, subject to erosion and sediment control requirements of the Land Resources Commission

- If rinsate meets drinking water standards but not water quality-based limits, spent ore may be off-loaded to a pit with no surface water discharge

- If neither drinking water standards nor water quality-based limits are met, the material may have to be encapsulated to prevent discharge to either surface or ground water and would be subject to applicable requirements of DHEC's Bureau of Solid and Hazardous Waste.

Heap reclamation activities will involve grading of side slopes to an overall slope of 3H:1V and revegetating, with added provisions for runoff control and stabilization, as heap slumping has been a problem at the facility in the past (Brewer Gold Company, 1990b). Problems with slumping and excess sediment in rinse ponds had led to a temporary suspension of rinsing on pads 1 through 4; these pads were being regraded and reshaped to a slope of 3H:1V and revegetated before rinsing was continued (Brewer Gold Company, 1991f). This is intended to stabilize the slopes and enhance percolation. During the site visit, it was observed that some slopes of pads 1 through 4 had well-established grasses.

Brewer has proposed that at closure, intermediate bench slopes be graded to control surface runoff and erosion. All final slopes will be covered with topsoil, fertilized, and revegetated. In addition, the leachate collection pond will be maintained to collect subsequent leachate from heaps due to incidental precipitation. The pond will be graded to provide gravity flow to the treatment plant or provided with a pumping system. The treatment plant will be operated and the leachate monitored until such time as water quality of the leachate allows other options to be used (Brewer Gold Company, 1990b).

2.3.4 Sediment Pond

The Brewer operation is intended to be a closed system. However, the facility is periodically faced with excess water resulting from precipitation. This water, which can be runoff or excess process water, is treated in a cyanide destruct unit (as noted above, originally a calcium hypochlorite system and now involving hydrogen peroxide treatment and flocculation as well) before being directed to the Sediment Pond. From the Sediment Pond, water can re-enter the process or rinsing circuits or be discharged via NPDES permit.

The Sediment Pond dam is about 55 feet high with a crest elevation of 420 feet above sea level. The upstream and downstream faces are sloped at 2.5:1 and 3:1, respectively. A 15-foot wide bench, at an elevation of approximately 388 feet, was included in the downstream face of the dam. The dam is a zoned earthen structure constructed with a clay core set into a shallow trench, compacted silty gravelly shells, and chimney and blanket drains. An emergency spillway was cut through bedrock to the east of the left abutment (Steffen Robertson & Kirsten, 1987). The pond was permitted at 846,000 gallons (DHEC, 1987a) and is unlined.

At the pond, lime is used to adjust pH and flocculants are added to reduce the levels of metals in the water. When necessary, treated water is discharged via a pipeline to a permitted outfall (designated outfall 001 in the facility's NPDES permit). Discharge is not continuous; treatment and batch discharges occur when excess process water and storm water accumulate. Approximately 32 million gallons of excess water were said to be treated and discharged from the Brewer Mine annually (EPA, 1991).

Table 2-2 presents flows to (outfall 002) the Sediment Pond and from (outfall 001) and concentrations of selected parameters from March through August 1991. Data were taken from Brewer's monthly NPDES discharge monitoring reports (Brewer Gold Company, 1991c).

Table 2-2. Concentrations of Selected Parameters in Discharges from Outfalls 001 and 002 [1]

(all concentrations in milligrams per liter except pH)

Parameter	Month (1991)					
	March	**April**	**May**	**June**	**July**	**August**
Outfall 001: Sediment Pond discharge to Little Fork Creek						
Total Flow (10^6 gallons)	13.199	No discharge	13.237	No discharge	13.733	4.331
pH (s.u.)	8.5[2]		8.9[2]		8.4[2]	8.8[2]
Cyanide	0.120		0.134		0.035	0.107
Copper	0.048		0.084		0.183[2]	0.026
Mercury	< 0.0002		< 0.0002		< 0.0002	0.00036
Outfall 002: Cyanide Destruct Unit discharge to Sediment Pond						
Total flow (10^6 gallons)	4.041	4.256	1.206	5.400	4.134	2.160
pH (s.u.)	10.2	10.72	10.35	11.05	10.58	11.42
Cyanide	6.13	7.68	2.4	4.35	4.28	7.21
Copper	132.	148.	36.9	40.	47.3	35.5
Mercury	0.0011	0.0011	0.0103	0.006	0.0144	0.0009

1. See Table 4 for effluent limits in NPDES Permit SC0040657 on outfall 001.
2. Value shown is highest value reported (n = 2).

Source: Brewer Gold Company, 1991c.

As noted previously, Brewer's draft revised NPDES permit calls for effluent from the pit water treatment system to be discharged to the Sediment Pond through internal outfall 002 prior to its discharge through outfall 001. According to Brewer representatives, this will begin upon State approval of the system (which, according to the State, was obtained in early 1992).

As described in section 2.4.1.1, Brewer monitors ground water in three wells near the waste rock pile and Sediment Pond. Results of monitoring are presented in that section.

Upon closure, remaining solutions will be treated and discharged as required in the facility's NPDES permit. Treatment will likely involve hydrogen peroxide cyanide destruction and flocculation to further decrease metals (particularly copper). The pond itself will remain after closure.

At the time of the site visit, Brewer Gold Mining Company was searching for a market for the process sludge that may be recovered, which was expected to be rich in copper. If a market could not be found, the sludge was to be geochemically immobilized with cement and encapsulated in place or moved to an alternative site for disposal (Brewer Gold Company, 1991f). During the site visit, Brewer representatives indicated that less than an inch of sludge had accumulated to date. No information was available on sludge characteristics.

2.3.5 Pad 6 Overflow Pond

In December 1989, Brewer Gold Company obtained a permit to construct what is now Heap Leach Pad 6 (DHEC, 1989b). This construction permit included provisions for an overflow pond associated with the pad. The pond had a capacity of 17.5 million gallons, and was double-lined, with a leak detection sump. The pond received excess solution from Pad 6. The pond was located in a natural drainageway just below Pad 6.

The original dam failed in October 1990, as described in more detail below. Following the failure, Brewer received new construction permits numbers 17,027 and 17,052 (DHEC, 1991b and 1991c; see Table 2-5) for pond redesign and reconstruction, respectively. The new pond's dam is an earthfill structure with a seal zone on the upstream face. A chimney drain connects to a horizontal toe drain. Permit 17,052 also required the construction of three movement monuments as well as two standpipe piezometers and three vibrating wire piezometers.

The pond itself has a 18.9 million gallon capacity and is lined (clay seal overlain by 60-mil HDPE primary and 40-mil HDPE secondary liners) with a geonet leak detection/recovery system between the HDPE liners. Underneath the liners is a network of drains (clean gravel with slotted pipe) to collect ground water. There is also a lined (60-mil HDPE) emergency overflow ditch that leads to an 18,000 gallon reinforced concrete outlet sump just below the dam, which also receives underdrain discharge and any water collected in the leak detection system.

As described in section 2.4.1.1, Brewer monitors ground water in one well near the pad 6 overflow pond as well as from the underdrains beneath the pond (the pond also has a leak detection sump that is monitored). Results of monitoring are presented in that section.

2.3.6 Solution Ponds

In addition to the Sediment Pond and Pad 6 Overflow Pond described above, the Brewer Gold facility currently operates a number of other solution ponds, all at the southern foot of Pads 1-4 near the carbon plant (see Figure 2-3). These ponds are described below.

<u>Barren Pond</u>. This 900,000 gallon pond (DHEC, 1987b), part of the original construction, is about seven feet deep with 2:1 side slopes. Like the rinse effluent pond described below, it was constructed with 40-mil HDPE and 20-mil PVC liners over 12 inches of compacted silty-clayey material. A leak detection system of polyethylene Gundnet and geofabric was installed between the synthetic liners (Steffen Robertson & Kirsten, 1987). Barren solution enters this pond directly from the carbon circuit. Because it is located immediately below Pads 1 through 4 and receives runoff from heaps and from the carbon plant, it also has received sediment from erosion (Brewer Gold Company, 1991f). Barren solution, according to a number of spill and leak reports, contains sodium cyanide at concentrations of 600 ppm or more. Solution from this pond is typically made-up with additional cyanide and re-applied to Pad 6, but may be treated and then discharged to the Sediment Pond or used as rinsewater.

<u>Rinse Effluent Pond</u>. This pond, the original pregnant pond for Pads 1 through 4, was permitted at 1,999,000 gallons (DHEC, 1987b). This pond is about seven feet deep with 2:1 side slopes. Like the barren pond, it was constructed with 40-mil HDPE and 20-mil PVC liners over 12 inches of compacted silty-clayey material. A leak detection system of polyethylene Gundnet and geofabric was installed between the synthetic liners (Steffen Robertson & Kirsten, 1987). It receives rinsate directly from Pads 1 through 4. As noted in section 2.3.3, problems with sedimentation in this pond and fines in the rinse treatment circuit had led, at the time of the site visit, to a cessation of rinsing of Pads 1 through 4 while the pads were being regraded, resloped, and revegetated. During the site visit, it was noted that significant amounts of sediment had accumulated in this pond. According to Brewer, the sludge/sediment in this pond is coarser than in other ponds (up to 1.5 inches in diameter). Should removal of the sediment/sludge be necessary, it would be placed back on one of the pads being rinsed (Brewer Gold Company, 1991f). Analytical data on sediment quality were not available.

<u>Rinse Reclaim Pond</u> (or Rinse Spray Pond). This pond (formerly the Rinse Pond) was also part of the original facility. It was apparently permitted at 8,900 gallons [DHEC, 1987b] but appeared during the site visit to have a capacity of several hundred thousand gallons. It is lined with 40-mil HDPE and 20-mil PVC over 12 inches of compacted silty-clayey material. A leak detection system of polyethylene Gundnet and geofabric was installed between the synthetic liners (Steffen Robertson & Kirsten, 1987). The pond receives treated water from the cyanide destruct unit prior to re-application to pads under rinse. As of January 1991, it contained about 4.1 inches of sludge with a 23 percent solids content. Sludges are metal hydroxides, primarily copper hydroxide: the sludge is approximately 15 percent copper (Brewer Gold Company, 1991d).

Emergency Pond (or Effluent Settling Pond). This 3,000,000 gallon pond receives overflow from the rinse effluent pond (the former pregnant pond) and may also be used to store other excess waters. Details on its construction were not available, although Brewer indicated it is double-lined with a leak detection system. The only information on cyanide concentrations came from an incident in January 1989, when there was significant leakage into the pond's french drain. At that time, sodium cyanide concentrations averaged about 300 ppm, and pH averaged about 10 (Brewer Gold Company, 1989).

Pit Water Treatment Pond. This 3,500,000 gallon pond was constructed in 1990-1991. The original construction permit (issued October 29, 1990) authorized a 1,000,000 gallon pond and a pit water treatment system. With the permit in place, a lined pond was constructed after the failure of the Pad 6 Overflow Pond (see sections 2.3.5 and 2.4.4.14) to provide emergency storage for solution from Pad 6 and storm water. This pond was constructed with a 3,500,000 gallon capacity, a primary liner of 60-mil HDPE, a secondary liner of 20-mil VLDPE over one foot of compacted clay, and a leak detection sump between the liners. The pond was to receive process wastewater until the Pad 6 overflow pond was rebuilt. This pond, with increased capacity and a revised pit water treatment system, was reissued a construction permit, which superseded the original permit, on October 29, 1991. (Because this permit was in preparation at the time of the site visit and was issued shortly thereafter, it was not examined by the site visit team; rather, it was described by DHEC in comments on a preliminary draft of this report).

The pond will receive water from the pit water treatment system once that system is placed in operation (as noted previously, the system received its operating permit in early 1992). Water from the pond will feed the rinse circuit or be discharged to the Sediment Pond. Sludges are expected to contain high levels of copper and iron hydroxides (over 15 percent copper) and Brewer anticipates finding a market for the sludges before closure (Brewer Gold Company, 1991f).

Carbon Fines Pond. This small pond is used to settle carbon fines. Details on the pond were not obtained. As noted previously, fines are periodically removed for precious metals recovery.

As described in section 2.4.1.1, Brewer monitors ground water in four wells near the solution ponds. Results of monitoring are presented in that section.

A number of options for sludge disposal at or before closure are being considered. Brewer will search for markets for metal-laden sediments. Alternatively, sludges may be enveloped in the plastic liners and heat-sealed or they may be geochemically immobilized (by fixation in cement). Brewer's tentative reclamation plans for ponds included folding and burying of liners and backfilling or breaching of pond areas. (Brewer Gold Company, 1990b and 1991d) According to the Land Resources Commission, Brewer will be required to remove all pond liners at closure to allow for proper disposal at a licensed waste disposal site.

2.3.7 Other Wastes and Materials

Table 2-3 lists other wastes and materials generated at the Brewer Gold Company facility and the means by which they are managed.

Table 2-3. Other Materials and Management Practices, Brewer Gold Company

Waste	Management Practice
Spent Carbon	Sent off-site for additional gold recovery by an outside firm (calculated to be approximately 1,500 tons per year)
Sanitary Sewage	Managed in an on-site leach field
Solid Waste	Local "trash" collection pickup
Used Oils	Stored in on-site tanks and sent off-site via purchaser or recycler (approximately 1,500 gallons per month, but varies with facility production rates)
Laboratory Wastes	Liquid lab wastes are added to the process water circuit at the rinse or barren stage; solid lab wastes (e.g., broken glass) are disposed with solid waste. Management of cuttings and drill cores was not determined.
Spent Solvents	Safety-Kleen supplies and picks up solvents used for metal cleaning (quantities not determined)

2.4 REGULATORY REQUIREMENTS AND COMPLIANCE

A number of State agencies are responsible for regulating various aspects of Brewer Gold's operations. These agencies, permits they have issued to Brewer, and the permits' major requirements, are described below.

2.4.1 South Carolina Department of Health and Environmental Control

2.4.1.1 Bureau of Water Pollution Control

The Bureau of Water Pollution Control (WPC) within DHEC is charged with protecting surface and ground waters of the State. With respect to the Brewer facility, the Bureau's authority stems from the Clean Water Act (CWA) and the South Carolina Pollution Control Act (PCA). Applicable regulations include: SC Regulation 61-9 (NPDES Permits), SC Regulation 61-68 (Preparation and Submission of Engineering Reports); SC Regulation 61-68, -69 (Water Classification and Standards); and SC Regulation 61-71 (Well Standards and Regulations).

The Bureau's authority over the facility extends as long as there are potential impacts to surrounding waters, from construction through post-closure. The Bureau's program is implemented through permitting systems, violations of which can result in the issuance of consent orders or administrative orders as well as civil and criminal actions. The Bureau has issued an NPDES permit to Brewer Gold Company for surface water discharges, as well as construction permits for facility components, which include ground-water monitoring requirements. These permits and their major requirements are discussed below.

NPDES Permit SC0040657 (DHEC, 1986 and 1990c). Brewer Gold Company's NPDES permit was originally issued in November 1986, with an expiration date in November 1991. Modifications to the permit were to be effective December 1, 1990; the expiration date was to be November 30, 1995. As noted below, however, Brewer adjudicated certain provisions of the modified permit, which stayed their effectiveness. According to DHEC, a revised draft permit was in its final stages of revision at the time of the site visit and was expected to be issued in the near future.

Table 2-4. Effluent Limits[1] in Brewer Gold Company NPDES Permit SC0040657

(units in milligrams per liter except pH)

Parameter[2]	NPDES Permit Effective December 1, 1986		Revised Draft Permit (to be issued in near future)			
	Daily Average	Daily Maximum	Monthly Average	Daily Maximum	Monthly Average	Daily Maximum
	mg/L		lbs/MG[4]		mg/L	
TSS	20	30	-	-	20	30
Oil and Grease	10	15	-	-	10	15
Total Residual Chlorine	0.352	0.608	0.835	1.67	0.5	1.0
Cyanide	0.166	0.332	0.0835[3]	0.167[3]	0.65[3]	1.2[3]
Arsenic	6.0	11.5	0.417	0.835	-	-
Copper	0.150	0.300	0.0835	0.167	0.15	0.30
Lead	0.050	0.084	0.417	0.835	0.3	0.6
Mercury	0.00038	0.00076	0.00167	0.00334	0.001	0.002
Zinc	0.75	1.5	0.392	0.784	0.75	1.5
Cadmium	0.021	0.042	0.0835	0.167	0.05	0.10
Silver	0.038	0.076	0.25	0.5	-	-
Molybdenum	22	44	2.09	4.18	-	-
Aluminum	-	-	0.726	6.26	-	-
pH (s.u.)	6.0 - 9.0		6.0 to 9.0		6.0 to 9.0	

[1] Although the 1986 permit did not specify species for parameters, Discharge Monitoring Reports did require totals. Limits in the revised draft permit are on totals (e.g., total cyanide, total copper).

[2] Monitoring requirements specify grab samples taken once per discharge, up to two samples per month. The revised draft permit requires weekly samples.

[3] Brewer has petitioned to have cyanide limits reflect weak acid dissociable cyanide. Limits on total cyanide were stayed pending resolution. The revised draft permit requires analysis for total cyanide.

[4] MG = million gallons streamflow in Little Fork Creek.

Sources: DHEC, 1986 and 1990c.

The original (and the new draft) permit authorizes a discharge of process wastewater and stormwater from the Sediment Pond to Little Fork Creek. In the original permit, the volume of discharge permitted is dependent on the differential between the annual precipitation falling on the facility and the drainage area contributing to surface runoff to the treatment facility, and annual evaporation. To this end, Brewer is required to report, on an annual basis, the total amount of effluent discharged, the total volume of precipitation, and the evaporation for the preceding year (the capacity of the treatment system is about 600 gpm, which effectively limits discharges to that level). Table 2-4 shows effluent limits in the original permit. The revised draft NPDES permit is based on a controlled discharge of poundage per million gallons of streamflow in Little Fork Creek (i.e., so many pounds of a pollutant per million gallons of streamflow). In addition, monthly discharge monitoring reports are submitted to DHEC. These reports include flow measurements as well as effluent monitoring data.

The revised draft permit also was to establish a second permitted NPDES outfall (002). This is an internal outfall located at the point where plant process water is discharged to the Sediment Pond. Under the permit, the facility is required to monitor outfall 002 and report monthly on levels of the following parameters: Flow, TSS, Copper (Total), Lead (Total), Mercury (Total), Zinc (Total), Cadmium (Total), Cyanide (Total), pH, floating solids, visible foams, and visible sheen (DHEC, 1990c).

Other major alterations in the revised draft permit include changes in effluent limits, as shown in Table 2-4. In addition, Brewer was required to install a high rate diffuser (in lieu of acute toxicity testing of effluent) and conduct macroinvertebrate studies in Little Fork Creek three times per year. Brewer must record streamflow, effluent flow, and the ratio during discharges to verify compliance (DHEC, 1990c). The facility has a U.S. Geological Survey gaging station in Little Fork Creek to make these measurements.

Brewer petitioned DHEC to reconsider two of the requirements in the 1990 modifications to the NPDES permit: the dilution factor, which DHEC had established at less than 75 to 1 (i.e., the instantaneous ratio of streamflow to effluent discharge would have had to be 75 or greater--Brewer requested that it be lower during periods after heavy precipitation conditions); and the discharge limits for cyanide, which were based on total cyanide (Brewer requested that it be based on weak acid dissociable cyanide). As noted above, these provisions of the modified permit were stayed pending resolution; because the dilution factor affected essentially the entire permit, the existing (1986) permit was effective pending resolution of the revised draft permit (DHEC, 1990c; Haynsworth, Baldwin, Johnson and Greaves, 1990; Brewer Gold Company, 1990i and 1991d). According to DHEC, the dilution factor issue has been addressed in the revised draft NPDES permit by changing to a basis of poundage per million gallons of streamflow in Little Fork Creek and the method for analysis for cyanide has remained total cyanide.

If Brewer's monthly discharge monitoring reports show that effluent limits in the NPDES permit have been exceeded by a small amount, DHEC requires the facility to explain the excursion and the reasons (e.g., laboratory error, operator error). If there are significant violations or continuing violations that are not brought under control, DHEC may require sampling and possibly take enforcement actions.

Construction Permits. In addition to the NPDES permit, the Bureau of Water Pollution Control has issued 11 construction permits to Brewer Gold Company. Table 2-5 below lists these permits, the activity or facility component/operation covered, and major permit requirements.

Table 2-5. Construction Permits Issued to Brewer Gold Company

Permit Number	Issue Date	Nature of Permit	Major Requirements
13,135	4/87	Sediment Pond (846,000 gallon capacity)	N/A
13,172	5/87	Original Facilities (600 gpm hypochlorite cyanide treatment system, 54,000 gallon treated water holding pond, and recirculated process system: 1,999,000 gallon pregnant pond, 901,000 gallon barren pond, 8,900 gallon rinse water pond, four 180,000 feet leach pads and associated piping)	• Submit BMP plan, maintain O&M manual onsite • Monitor cyanide wastewater treatment system once per discharge for 13 parameters[a] • Monitor leak detection sumps of barren, carbon, and pregnant ponds for liquid, pH, and total cyanide • Pipe underdrain discharges from closed-out leach pads to Sediment Pond • Sample groundwater monitoring wells quarterly for 32 parameters[b] • Sample emergency spillway discharge, if any, from rinsewater pond for 13 parameters[a] • Submit QA plan for installation of liner system • Allow no overspray of cyanide process solution out of heap leach containment area • Submit plan for approval prior to rinsing heap leach pad for closure
14,217	5/88	Pad 5 (Add 780 feet by 545 feet on-off asphalt-lined leach pad with French drain leak detection system, two 1,000 gallon two stage solution sumps, leak detection sump, 3.6 million gallon pregnant pond, associated piping and appurtenances).	• Monitor pregnant pond leak detection sump for liquid, pH, and total cyanide • Obtain DHEC approval before placing spent ore from Pad 5 on Pads 1-4 • Submit closure plan for pad at least six months prior to end of operations • Install groundwater monitoring well near pregnant pond • Monitor leak detection sumps of barren, carbon, pregnant, rinse, and emergency ponds weekly for the life of the project for presence of liquid, pH, and total cyanide

[a]Including pH, total cyanide, cyanide, thiocyanate, total residual chlorine, copper, zinc, lead, mercury, cadmium, TSS, flow, and ammonia.

[b]Including pH, conductivity, hardness (as $CaCO_3$), alkalinity, carbon, TKN, ammonia, nitrite, nitrate, phosphorus, chloride, turbidity, mercury, potassium, manganese, calcium, iron, sodium, magnesium, aluminum, barium, cadmium, chromium, copper, silver, zinc, arsenic, lead, selenium, TDS, sulfate, and total cyanide.

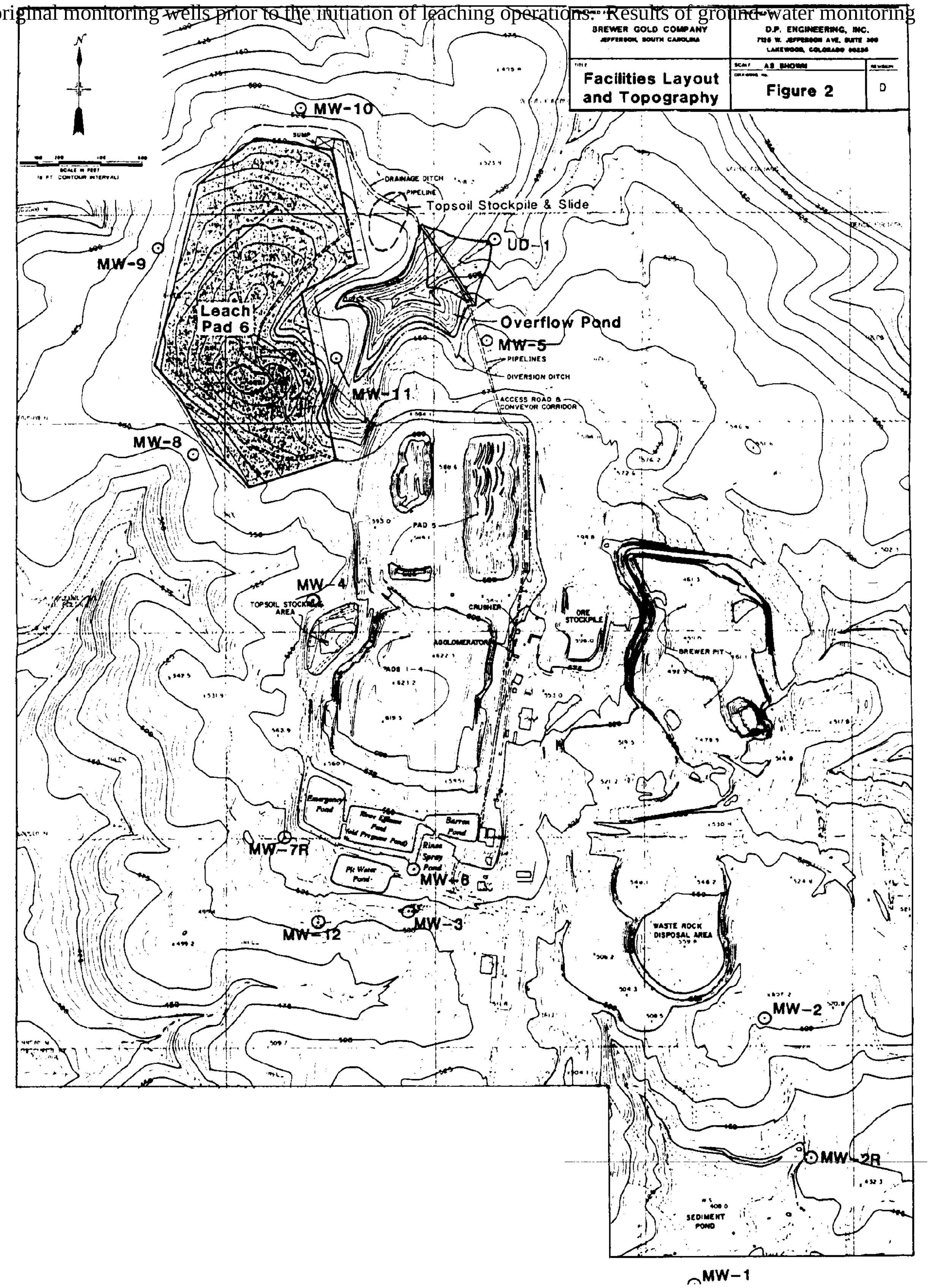
Table 2-5. Construction Permits Issued to Brewer Gold Company (continued)

Permit Number	Issue Date	Nature of Permit	Major Requirements
15,697	9/89	Pad 5A (Post-construction approval for 60,000 square feet leach pad and modification of Pad 5 from a reusable leach pad to a dedicated leach pad).	• Submit QA/QC plan for construction and installation of Pad 5A • Submit closure plan for Pad 5A within 6 months of permit issuance • Allow no overspray of cyanide process solution out of heap containment area
15,699	9/89	Sediment Pond Flocculation System (Flocculation system for the sediment pond: one 1,000 gpm (60 hp) pump, piping, metering pumps, 1,250 gallon steel mixing tank with mixer).	• Water pumped from pond for use in dust control must comply with NPDES permit effluent limits • Submit closure plan for pond within six months of permit issuance
15,869	12/89	Pad 6 (1,100,000 square foot heap leach pad with leak detection sump and 10,000 gallon collection sump and associated pumps and piping, and 17.5 million gallon pond and leak detection sump and associated pumps and piping).	• Update BMP plan • Monitor leak detection sumps of Pad 6 and Pad 6 overflow weekly for the life of the project for liquid, pH, and total cyanide • Sample groundwater monitoring wells and underdrain quarterly for 32 parameters[2] • Submit "worst case" contingency closure plan for Pads 1-5A and Pad 6 • Operate so as to avoid discharge from pond spillway • Minimum standards for sampling of heaps after rinsing during heap closure and reclamation • Install groundwater monitoring wells • Place ore for leaching on Pad 6 no closer than 20 feet from perimeter berms and/or solution ditches
16,255	5/90	Hydrogen Peroxide Rinse System (Modification of the chlorine rinsewater treatment system consisting of an existing 20,000 gallon carbon steel tank modified with internal baffles, hydrogen peroxide storage and metering system and associated piping and appurtenances).	• Submit sludge disposal plan within six months of permit issuance • Maintain O&M manual for waste treatment plant onsite • Update BMP plan

Table 2-5. Construction Permits Issued to Brewer Gold Company (continued)

Permit Number	Issue Date	Nature of Permit	Major Requirements
16,727 Superseded by 17,170	10/90 10/91	Pit Water Treatment System and Pond (permit 17,170) (Existing 3,500,000 gallon pond with 60-mil HDPE primary liner, 20-mil VLDPE secondary liner on one-foot compacted clay base, and leak detection system between liners; pit water treatment system equipment and piping.	• Maintain O&M Manual for treatment plant on site • Submit updated BMP plan • Submit deactivation plan prior to temporary cessation of mining activity • Maintain daily log on use of pit water for dust control • Report any overflows from spillway
17,027	4/91	Pad 6 Overflow Pond Redesign (Leak collection and recovery system including construction of a concrete pipe encasement with 6" and 10" diameter HDPE pipe, two concrete cutoff collars, portion of clay backfill which supports encasement and portion of toe drain which supports encasement).	N/A
17,052	5/91	Pad 6 Overflow Pond Reconstruction (Rehabilitation and reconstruction of the Pad 6 Overflow Pond: 1) zoned earthfill structure with seal zone on an upstream face, with chimney drain connected to horizontal toe drain; (2) impoundment with storage capacity of 18,900,000 gallons, emergency spillway, liner system [clay seal zone beneath 60 mil HDPE primary liner and 40 mil VLDPE secondary liner, with geonet leak collection and recovery system between secondary and primary liners, extra layer of 60 mil HDPE placed at the outflow of the overflow ditch, and leak detection sump consisting of clean gravel between 60 mil and 40 mil liners with volume of approximately 5,400 gallons]; (3) network of groundwater drains under liner system [clean gravel surrounded by geotextile, with slotted diameter pipe with minimum cross-section of 10 square feet, and removal and backfill with clay of some of previous pond groundwater drains]; (4) relining with 60 mil HDPE section of existing overflow ditch from Pad 6 to Overflow pond; (5) reinforced 10,000 gallon concrete outlet sump outlet piping, pump with 2" diameter HDPE piping encased in 4" diameter CPT pipe; (6) three movement monuments, two toe monuments, two standpipe piezometers, and three vibrating wire piezometers; and (7) associated piping and appurtenances).	• Update BMP plan • Monitor leak detection sumps of Pad 6 and overflow pond weekly for the life of the project for liquid, pH, and total cyanide • Monitor groundwater underdrainage weekly for pH, flow, and free cyanide • Maintain emergency generator onsite • Maintain O&M for waste treatment plant onsite

These permits, as can be seen, have authorized construction and operation of all facility components. They typically require submission of various engineering, operating, and maintenance reports and studies. These construction permits also require monitoring of ground water near each major facility component and closure plans for facility components. Altogether, there are 13 ground-water monitoring wells: three for the Sediment Pond and waste rock piles, four for the solution ponds, four for Pad 6, one for the Pad 6 overflow pond (underdrainage from this pond is also monitored), and one to the west of Pads 1-5. Locations of monitoring wells are shown in Figure 2-4. Background water quality was established by sampling the original monitoring wells prior to the initiation of leaching operations. Results of ground-water monitoring



US EPA ARCHIVE DOCUMENT

Table 2-9. Monitoring Data From Well Located Near Pad 6 Overflow Pond and From Pad 6 Overflow Pond Underdrain

Monitoring Well/ Parameter	Minimum and Maximum Concentrations Detected (ppm, Except as Noted)			
	1988	1989	1990	1991
MW-5	n = 4	n = 4	n = 4	n = 2
pH (s.u.)	4.0 - 4.7	4.65 - 6.18	3.89 - 4.25	4.29 - 3.98
Total Cyanide	<0.01 - <0.01	<0.05 - <0.01	<0.01 - <0.01	<0.01 - 0.043
Cadmium	<0.01 - <0.01	<0.01 - <0.01	<0.01 - 0.01	<0.001 - 0.004
Copper	<0.1 - <0.1	<0.03 - 0.14	0.09 - 0.84	0.13 - 1.51
Mercury (ppb)	<2 - <2	<0.2 - <2	0.38 - 5.45	0.5 - 0.8
UD-1	n = 0	n = 0	n = 4	n = 2
pH (s.u.)	N/A	N/A	4.33 - 4.95 (n = 3)	4.79 - 5.2
Total Cyanide	N/A	N/A	<0.01 - 89.3	<0.01 - 0.094
Cadmium	N/A	N/A	<0.01 - 0.0001 (n = 3)	<0.001 - <0.001
Copper	N/A	N/A	0.96 - 1.59 (n = 3)	0.112 - 0.378
Mercury (ppb)	N/A	N/A	<0.2 - 1.3 (n = 3)	0.3 - 0.5

Source: Compiled from Brewer Gold Company, 1991a.

from 1988 to 1991 for five selected parameters are presented in Tables 2-6

Table 2-6. Monitoring Data From Wells Located Near Sediment Pond and Waste Rock Disposal Area

Monitoring Well/ Parameter	Minimum and Maximum Concentrations Detected (ppm, Except as Noted)			
	1988	1989	1990	1991
MW-1	n = 4	n = 4	n = 4	n = 2
pH (s.u.)	4.7 - 5.9	4.48 - 4.9	3.08 - 4.67	3.99 - 4.26
Total Cyanide	<0.01 - <0.01	<0.05 - <0.01	<0.01 - <0.01	<0.01 - <0.01
Cadmium	<0.01 - <0.01	<0.01 - <0.01	0.0001 - <0.01	<0.001 - 0.002
Copper	<0.1 - <0.1	<0.03 - <0.1	<0.03 - <0.05	0.1 - 0.139
Mercury (ppb)	<2 - <2	<0.2 - 4	<0.2 - 1.55	<0.2 - 0.6
MW-2	n = 4	n = 4	n = 1	n = 0
pH (s.u.)	3.8 - 4.2	4.06 - 4.14	3.9	N/A
Total Cyanide	<0.01 - <0.01	<0.01 - <0.05	<0.01	N/A
Cadmium	<0.01 - <0.01	<0.01 - <0.01	<0.01	N/A
Copper	<0.1 - <0.1	<0.03 - <0.1	<0.03	N/A
Mercury (ppb)	<2 - 6.1	<0.2 - <2	<0.2	N/A
MW-2R	n = 0	n = 0	n = 3	n = 2
pH (s.u.)	N/A	N/A	5.6 - 5.89	5.54 - 6.43
Total Cyanide	N/A	N/A	<0.01 - <0.01	<0.01 - <0.01
Cadmium	N/A	N/A	0.0001 - <0.01	<0.001 - <0.001
Copper	N/A	N/A	<0.03 - <0.05	0.003 - 0.013
Mercury (ppb)	N/A	N/A	0.16 - 0.18	0.21 - 0.36

SOURCE: Compiled from Brewer Gold Company, 1991a.

through

Table 2-7. Monitoring Data From Wells Located Near Solution Ponds

Monitoring Well/ Parameter	Minimum and Maximum Concentrations Detected (ppm, Except as Noted)			
	1988	1989	1990	1991
MW-3	n = 4	n = 4	n = 4	n = 2
pH (s.u.)	4.1 - 4.6	4.06 - 4.73	4.19 - 4.67	4.33 - 4.57
Total Cyanide	<0.01 - <0.01	<0.05 - <0.01	<0.01 - <0.01	<0.01 - <0.01
Cadmium	<0.01 - <0.01	<0.01 - <0.01	<0.0001 - <0.01	<0.001 - <0.001
Copper	<0.1 - <0.1	<0.03 - 0.04	<0.03 - <0.05	0.023 - 0.155
Mercury (ppb)	<2 - 2	0.2 - <2	<0.2 - 1.43	0.5 - 0.6
MW-6*	n = 0	n = 0	n = 0	n = 0
MW-7R	n = 0	n = 0	n = 4	n = 2
pH (s.u.)	N/A	N/A	3.89 - 4.88	5.54 - 6.43
Total Cyanide	N/A	N/A	<0.01 - <0.01	<0.01 - <0.01
Cadmium	N/A	N/A	<0.010 - 0.0001	<0.001 - <0.001
Copper	N/A	N/A	<0.03 - 0.04	0.004 - 0.009
Mercury (ppb)	N/A	N/A	3.5 - 7.7 (n = 3)	1.2 - 5.2
MW-12	n = 0	n = 0	n = 0	n = 1
pH (s.u.)	N/A	N/A	N/A	4.39
Total Cyanide	N/A	N/A	N/A	<0.01
Cadmium	N/A	N/A	N/A	<0.001
Copper	N/A	N/A	N/A	0.017
Mercury (ppb)	N/A	N/A	N/A	2.6

* Well has remained dry since construction.

SOURCE: Compiled from Brewer Gold Company, 1991a

Table 2-8. Monitoring Data From Wells Located Near Leach Pad 6

Monitoring Well/ Parameter	Minimum and Maximum Concentrations Detected (ppm, Except as Noted)			
	1988	1989	1990	1991
MW-8	n = 0	n = 0	n = 4	n = 2
pH (s.u.)	N/A	N/A	4.67 - 5.69	4.53 - 4.67
Total Cyanide	N/A	N/A	<0.01 - 0.04 (n = 5)	<0.01 - <0.01
Cadmium	N/A	N/A	<0.010 - <0.0001	<0.001 - <0.001
Copper	N/A	N/A	<0.03 - <0.05	0.005 - 0.01
Mercury (ppb)	N/A	N/A	<0.2 - 0.26	<0.2 - 0.3
MW-9	n = 0	n = 0	n = 4	n = 2
pH (s.u.)	N/A	N/A	4.7 - 4.9	4.61 - 4.68
Total Cyanide	N/A	N/A	<0.01 - <0.01	<0.01 - <0.01
Cadmium	N/A	N/A	<0.010 - 0.0001	<0.001 - <0.001
Copper	N/A	N/A	<0.03 - <0.05	0.005 - 0.015
Mercury (ppb)	N/A	N/A	<0.2 - 1	<0.2 - <0.2
MW-10	n = 0	n = 0	n = 4	n = 2
pH (s.u.)	N/A	N/A	4.59 - 4.72	4.48 - 4.58
Total Cyanide	N/A	N/A	<0.01 - <0.01	<0.01 - <0.01
Cadmium	N/A	N/A	<0.010 - 0.0001	<0.001 - 0.002
Copper	N/A	N/A	<0.03 - <0.05	0.003 - 0.004
Mercury (ppb)	N/A	N/A	<0.2 - 0.4	<0.2 - 0.7
MW-11	n = 0	n = 0	n = 4	n = 2
pH (s.u.)	N/A	N/A	4.33 - 4.66	4.4 - 4.7
Total Cyanide	N/A	N/A	<0.01 - <0.01	<0.01 - <0.01
Cadmium	N/A	N/A	<0.010 - 0.0001	<0.001 - 0.001
Copper	N/A	N/A	<0.03 - <0.05	0.004 - 0.072
Mercury (ppb)	N/A	N/A	<0.2 - 0.5	<0.2 - <0.2

SOURCE: Compiled from Brewer Gold Company, 1991a

2-10. Background data were not available.

Should ground-water monitoring reveal a continuing violation of State drinking water standards (one-time excursions would be verified before formal action was taken), DHEC could impose civil or criminal penalties and/or require source control or remediation action. This has not been necessary to date.

Sewage Treatment and Disposal System Permit. In addition to the permits discussed above, DHEC's Bureau of Environmental Health, Division of On Site Waste Management also issued, in July, 1987, Sewage Treatment and Disposal System Permit No. 13-62778 for a domestic sewage drain field. This permit was not examined by the site visit team.

2.4.1.2 Bureau of Air Quality Control

DHEC's Bureau of Air Quality Control issues and enforces Air Emissions Permits under the South Carolina Pollution Control Act and State Regulation 61-62.1. The Brewer Gold Company facility has been issued a five-year operating permit (March 1989 - March 1994) and a construction permit. Brewer's Permit No. 0660-0026, effective from March 20, 1989 through March 31, 1994, authorizes operation of the following units (DHEC, 1989c):

- ID No. 01: 400 ton/hour primary, secondary, and agglomerating plant. The permit required Brewer to install water sprays for dust control in these areas.
- ID No. 02: 40 ton capacity cement storage silo with fabric sock or bin vents.
- ID No. 03: 1,000 gpm sodium cyanide leaching process for gold recovery with pH controlled to greater than 10.5. Hydrogen cyanide concentrations may not exceed 250 micrograms per cubic meter at the plant boundary on a 24-hour basis.
- ID No. 04: 15 pound/hour propane fired melting furnace for dore production.

Table 2-11 shows emission limitations established by the permit for these units. In addition to these limits, the permit makes the facility subject to applicable New Source Performance Standards for Metallic Mineral Processing (40 *CFR* Part 60, Subpart LL). The permit also requires that dust from haul roads and turnaround areas be controlled by water sprays and water trucks and that stockpiles or waste rock piles be sprayed with water when wind erosion creates excessive emissions (DHEC, 1989c).

Table 2-11. Emission Limits Established by Permit 0660-0066

Unit ID	Pollutant	Emission Limitation
01	PM	22.4 pounds/hour or 98.11 tons/year
	Opacity	10 percent
02	PM	10.125 pounds/day or 1.85 tons/year
	Opacity	20 percent
03	Opacity	20 percent
04	Mercury	0.0003 pound/hour or 0.0013 ton/year
	Arsenic	0.01 pound/hour or 0.0044 ton/year
	Opacity	20 percent

Source: DHEC, 1989c.

Permit No. 0660-0026-CE, issued in July 1990 and expiring after one year, authorized the construction of a 100-ton silo for storage of calcium cyanide to be pneumatically unloaded by trucks and controlled by a bin vent fabric filter and an in-line disposal cartridge filter. Table 2-12 shows the emission limitations for the storage silo (DHEC, 1990e). Operation of the silo requires an operating permit, which may have been issued about the time of the site visit (the silo was operating at the time of the visit).

Table 2-12. Emission Limits Established by Permit 0660-0026-CE

Pollutant	Emission Limitation
PM	0.0009 pound/hour or 0.004 ton/year
Hydrogen cyanide (HCN)	2.10 pounds/hour or 9.2 tons/year
Opacity	20 percent

Source: DHEC, 1990e.

The Bureau of Air Quality Control is authorized to seek civil and/or criminal penalties when permit requirements are violated by a facility. Formal facility inspections are conducted by DHEC's Florence District Office on an annual basis.

2.4.2 Land Resources Commission

2.4.2.1 Division of Mining and Reclamation Mining Permit 671

Under the South Carolina Mining Act (Section 48-20 of the State Code), the Division of Mining and Reclamation of the Land Resources Commission (LRC) is charged with ensuring that lands and waters involved in mining are protected and restored to the "greatest practical degree." LRC's responsibilities include issuing mining and reclamation permits, reviewing and approving reclamation plans, collecting reclamation bonds, and inspecting facilities to ensure compliance. LRC coordinates its activities with and supplements the regulatory activities of DHEC.

On July 16, 1986, LRC issued Mining Permit 671 for the Brewer facility (LRC, 1986); the permit has been modified a number of times since to reflect changes in facility components and operations. Table 2-13

Table 2-13. Major Requirements Established by Mine Permit 671

Facility/Operational Component	Major Requirements
Original Permit 671: July 16, 1986	
Ground water	• Characterize existing groundwater (depth, quality, etc.) • Establish background quality prior to leaching • Sample monthly and report to LRC
Leach Pads and Ponds	• Install dual liners for pads: 40-mil primary, 18-inch secondary with permeability < 1 x 10^{-7} • Pregnant and barren ponds: HDPE primary liner, ditches, etc.
Waste Rock	• Submit plan for acid-base testing • Establish alternative site for rock with acid generation potential
Cyanide Neutralization	• Reduce free cyanide in heaps to 0.2 ppm
Reclamation	• Outline study to project post-reclamation quality of pit water • Work with LRC on revegetation
Contingency Plans	• Develop plan to verify/locate/correct leaks if cyanide detected in groundwater • Develop plan for mitigation of heavy rainfall and high winds from hurricanes and storms
Notification	• Notify LRC of pad leaks or cyanide detected in groundwater
May 13, 1988 Modification: Pad 5	• Approval of asphalt pad for 10-cell on-off Pad 5 • Monitor leak detection sumps for free cyanide, pH, gold
September 15, 1989 Modification: Pads 5 and 5A	• Change Pad 5 to dedicated Pad, construct Pad 5A
October 23, 1989 Modification: Pads 5 and 5A	• Stack second lift (to 70 feet) on Pads 5 and 5A • Submit closure plan with six months • Begin rinsing Pads 1 through 5A by July 1, 1990, submit status report by September 15, 1990
November 7, 1989 Modification: Pad 6	• Clear Pad 6 area • Requirements to control runoff/sedimentation from construction area
December 8, 1989 Modification: Pad 6	• Construct Pad 6 • Submit wildlife hazing plan, fence Pad 6 pond

Source: LRC 1986, 1988a, 1989a, 1989b, 1989c, 1989d.

summarizes the requirements of Mining Permit 671. To ensure compliance, representatives of LRC make half-day inspections of the Brewer Gold Company facility on a monthly basis and longer inspections periodically.

Mining Permit 671 authorizes operation of the Brewer mine from July 1987 through September 1996. Initially, LRC required a reclamation bond of $170,000 (based on $1,000 per acre disturbed). This was raised to $230,000 in November 1989 because of increased land disturbance associated with Pad 6. Based on a subsequent Brewer estimate of the cost of completing its reclamation/closure plan, the bond was being raised to $500,000 (LRC, 1989a through d).

Brewer submitted a reclamation plan to LRC prior to operation. At the time, the S.C. Mining Act did not specify reclamation as a part of closure. As amended in 1990, the Act now states clearly that reclamation requirements for a mine facility are part of closure. Brewer's closure plans to date (Brewer Gold Company, 1990b) are conceptual in nature; a final closure plan will be required prior to actual closure.

Annual reclamation reports are required by LRC and are also required through construction permits issued by DHEC. General reclamation/closure activities required of Brewer by LRC include the following:

- Waste Rock Dump: sloping (3:1), revegetation of sides and tops with grasses interspersed with trees, and seepage/runoff pH testing
- Leach Pads: sloping (3:1), removal of solution lines, revegetation with grasses (may also require trees in the future)
- Ponds: removal of liners and bulldozing
- Physical Plants and Building Structures: removal
- Mine Pit: sloping of pit walls, revegetation, allowed to fill with water.The S.C. Mining Act, as amended in 1990, gives the LRC authority to assess civil penalties for noncompliance with the approved reclamation plan or schedule of reclamation. Penalties up to $1,000 per day per violation are authorized. In addition, LRC works closely with DHEC, which has additional authorities (as described above).

2.4.2.2 Engineering Division Dam Construction and Repair Permits

The LRC Engineering Division implements the Dam and Safety Reservoirs Act (section 49-11 of the State Code). LRC has issued Brewer three dam construction permits and one dam repair permit. These permits and the activity or facility component/operations covered are listed in Table 2-14. These permits were not examined by the site visit team.

Table 2-14. Dam Construction and Repair Permits Issued to Brewer Gold Company

Permit Number	Date Issued	Nature of Permit
13-447-P394	7/87	Sediment Pond Construction
13-537-P475	3/90	Overflow Pond Construction
13-527-P522	5/91	Pit Water Treatment Pond Construction
13-602-P522	6/91	Overflow Pond Dam Repair

2.4.3 Other Regulatory Agencies and Permits

The following permits have also been issued to the Brewer Gold Company:

- South Carolina Fire Marshal Blasting Permit No. 91-177
- U.S. Department of the Treasury - Bureau of Alcohol, Tobacco, and Firearms High Explosives License No. 1-SC-013-33-1L-92336

These permits were not examined by the site visit team.

2.5 REFERENCES

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A.S.C.I. 1990 (April). Abatement Plan for Potential Acid Mine Drainage Associated with Closure of the Brewer Mine. Prepared for Brewer Gold Company. Appendix A of Mine Closure Plan (Brewer Gold Company, April 1990a).

Brewer Gold Company. Undated. "Brewer Gold Mine." Unpublished brochure providing history and description of Brewer Gold Mine.

Brewer Gold Company (Westmont Mining Inc.). 1987a (March 27). Letter from R.J. McGregor, Brewer Gold Company to N. Weatherup, S.C. DHEC, RE: Response to March 24, 1987 letter from N. Weatherup, DHEC.

Brewer Gold Company. 1987b (December 23). Letter from W.T. Lyman, Brewer Gold Company to G. Stowe, S.C. DHEC, RE: Heap Pile Mud Flow, December 16, 1987.

Brewer Gold Company. 1988 (February 10). Letter from R.J. McGregor, Brewer Gold Company to J.W. Wilkinson, S.C. DHEC, RE: Request for extension of Consent Order 87-113-W, section 5 deadline.

Brewer Gold Company. 1988a (February 15). Letter from R.J. McGregor, Brewer Gold Company to N. Weatherup, S.C. DHEC, RE: leak detection system report.

Brewer Gold Company, 1988b (April 7). Letter from R.J. McGregor, Brewer Gold Company, to C. Kennedy, S.C. LRC, RE: Heap leach pad rinsing (remove Pad 1 from recirculation to begin rinsing).

Brewer Gold Company. 1988d (April 4 and 5). Letters from L. Harnage, Brewer Gold Company to R. Kinney, S.C. DHEC, RE: cyanide spill on March 31, 1988.

Brewer Gold Company. 1988e (April 22). Letter from R.J. McGregor, Brewer Gold Company, to E. Hart, S.C. DHEC, RE: Calculations on March 31 and April 5, 1988 spills of 600 ppm cyanide solution.

Brewer Gold Company. 1988f (June 24). Letter from J.J. Harrington, Brewer Gold Company to E. Hart, S.C. DHEC, RE: June 24, 1988 incident report.

Brewer Gold Company. 1989 (February 17). Letter from D. Williams, Brewer Gold Company, to E. Hart, S.C. DHEC, RE: Emergency Pond leak.

Brewer Gold Company. 1989a (February 27). Letter from J.B. Pautler, Brewer Gold Company to E. Hart, S.C. DHEC, RE: February 26, 1989 incident report.

Brewer Gold Company. 1989b (April 26). Memorandum to file from W.L. Rose, Brewer Gold Company; submitted to S.C. DHEC. Subject: Sediment pond discharge (and events surrounding).

Brewer Gold Company. 1989c (April 26). Letter from W.L. Rose, Brewer Gold Company, to N. Weatherup, S.C. DHEC, RE: response to DHEC letter dated 4/7/89 that requested information on rinsewater pond overflow, cyanide destruction system).

Brewer Gold Company. 1989d (July 20). Letter from J.B. Pautler, Brewer Gold Company to J. Wilkinson, S.C. DHEC, RE: report of spent ore slide and cyanide spill on July 16, 1989.

Brewer Gold Company. 1989e (July 28). Memorandum to file from W.L. Rose, Brewer Gold Company; submitted to S.C. DHEC. Subject: Sediment pond water treatment (including plant history), request for treatment and discharge.

Brewer Gold Company. 1990 (March 12). Letter from S. Wanstedt, Brewer Gold Company, to E. Hart, S.C. DHEC, RE: "Barren Pond Leakage" into leak detection sump.

Brewer Gold Company. 1990a (March 22 and April 3). Letters from S. Wanstedt, Brewer Gold Company, to K. Terry and E. Hart, S.C. DHEC, respectively, RE: Update on Pad 5 leakage. Includes memorandum to files from S. Wanstedt submitted to S.C. DHEC.

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Brewer Gold Company. 1990c (April 27). Letter from S. Wanstedt, Brewer Gold Company, to C. Kennedy, S.C. LRC, RE: Pad 6 slope failure preliminary report.

Brewer Gold Company. 1990d (April 27). Letter from S. Wanstedt, Brewer Gold Company, to B. Ruiter, S.C. DHEC, RE: "Use of hypochlorite...in the control of ... cyanide present in the clay liner due to the Pad 6 slope failure."

Brewer Gold Company. 1990e (August 22). Letter from S. Wanstedt, Brewer Gold Company, to J. Wilkinson, S.C. DHEC, RE: Incident report for August 20, 1990, cyanide spill.

Brewer Gold Company. 1990f (May 24). Letter from S. Wanstedt, Brewer Gold Company, to E. Hart, S.C. DHEC, RE: Notification of end of incident involving leakage from Pad 5 sumps.

Brewer Gold Company. 1990g (October 19). Letter from S. Wanstedt, Brewer Gold Company, to E. Hart, S.C. DHEC, RE: "Discharges from the Rinse and Sediment Pond emergency spillways" on October 10, 1990, and Summary of Events leading to discharges.

Brewer Gold Company. 1990h (October 26). Letter from S. Wanstedt, Brewer Gold Company, to G. Stowe, S.C. DHEC, RE: Description of leakage in leak detection system since October 10-11 storm.

Brewer Gold Company. 1990i (November 14). Letter from R.S. Mattson, Brewer Gold Company, to M.D. Jarrett, S.C. DHEC, RE: Request for administrative adjudicatory hearing raised by NPDES Permit No. SC0040657.

Brewer Gold Company. 1990j (November 27). Letter from S. Wanstedt, Brewer Gold Company, to J. Wilkinson, S.C. DHEC, RE: Discharges during October 1990 under NPDES Permit SC0040657 (letter accompanying October 1990 Discharge Monitoring Report).

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Brewer Gold Company. 1991d (May 14). Letter from R.C. Walish, Brewer Gold Company to B. McDade, S.C. DHEC, RE: response to April 26, 1991, letter requesting details of Brewer Gold Company's appeal to draft NPDES permit.

Brewer Gold Company. 1991e (June 17). "Brewer Rinsing Status Report and Schedule." Submitted by R. Walish, Brewer Gold Company, to J. Wilkinson, S.C. Department of Health and Environmental Control.

Brewer Gold Company. 1991f (July 12). "Treatment Pond Sludge Status Report and Sludge Disposal Schedule." Submitted by S. Wanstedt, Brewer Gold Company, to J. Wilkinson, S.C. Department of Health and Environmental Control.

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Sirrine Environmental Consultants. 1991 (April 8). Removal Action Assessment, Brewer Gold Company, Jefferson, South Carolina. Submitted to U.S. Environmental Protection Agency Region IV on behalf of Brewer Gold Company.

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State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1987a (April 14). Construction Permit 13,135 issued to Westmont Mining, Inc., Brewer Project (for construction of 846,000 gallon sedimentation pond).

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1987b (May 4). Construction Permit 13,172, with special conditions, issued to Brewer Mine (for construction of treatment tanks, 54,000 gallon holding pond, and recirculation process system [1,999,000 pregnant pond, 901,000 barren pond, 8,900 gallon rinse pond, four 180,000 square foot leach pads and associated piping]). Modified by permit special conditions in DHEC letter dated August 12, 1988 and in Construction Permit 16,255, issued May 24, 1991.

State of South Carolina, Department of Health and Environmental Control. 1987c (November 25). Consent Order 87-113-W; IN RE: Westmont Mining Inc./Brewer Gold Mine, NPDES No. SC0040657, Chesterfield County.

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1988b (May 16). Construction Permit 14,217, with special conditions, issued to Brewer Gold Company (for construction of asphalt leach pad [425,100 square feet] with french drain leak detection system, two 1,100 gallon two-stage solution pumps, leak detection sump, and 3,600,000 gallon pregnant pond with piping/appurtenances). Includes modifications to permit special conditions issued August 12, November 4, and December 14, 1988.

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1989a (September 26). Construction Permit 15,699, with special conditions, issued to Brewer Gold Company (for construction of flocculation system for sediment pond [and associated pumps, tanks, etc.]).

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1989b (December 8). Construction Permit 15,869, with special conditions, issued to Brewer Gold Company (for construction of Pad no. 6 [1,100,000 square feet, with leak detection sump, 10,000 gallon sump, associated pumps/piping]; and 17,500,000 gallon overflow pond and leak detection sump with associated pumps/piping.)

State of South Carolina, Department of Health and Environmental Control, Bureau of Air Pollution Control. 1989c (March 20). Operating Permit 0660-0026 issued to Brewer Gold Company.

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State of South Carolina, Department of Health and Environmental Control, Bureau of Air Pollution Control. 1990e (July 18). Construction Permit 0660-0026-CE issued to Brewer Gold Company.

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1990f (September 22). Construction Permit 15,697, with special conditions, issued to Brewer Gold Company (for construction of Pad 5A [60,000 square feet] and modification of Pad 5 from reusable to dedicated leach pad.]

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1990g (October 29). Construction Permit 16,727, with special conditions, issued to Brewer Gold Company (for construction of pit water treatment system [as described]).

State of South Carolina, Department of Health and Environmental Control, Water Pollution Assessment and Enforcement Division. 1991a (April 9). Notice of Enforcement Conference, NPDES Permit SC0040657, and Findings of Fact.

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1991b (April 12). Construction Permit 17,027, with special conditions, issued to Brewer Gold Company (for construction of leak detection and recovery system associated with redesigned Pad 6 overflow pond.)

State of South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control. 1991c (May 13). Construction Permit 17,052, with special conditions, issued to Brewer Gold Company (for redesigned Pad 6 overflow pond and dam).

State of South Carolina, Department of Health and Environmental Control. 1991d (June 6). Consent Order 91-30-W; IN RE: Brewer Gold Company, NPDES SC0040657, Chesterfield County.

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1986 (July 16). Brewer Mine, Permit No. 671, Additional Terms and Conditions.

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1988a (May 13). Approval and conditions for Brewer Gold Company application to modify permit 671 (modify leach pad liner from clay and synthetic liner and to deposit leached, rinsed ore on existing pads).

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1988b (July 28). Letter from C. Kennedy, S.C. LRC to J. Harrington, Brewer Gold Company, RE: Mining permit 671, Release of process solution from Pad no. 3 (500-600 gallons of 600-700 ppm pregnant solution).

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1989a (September 15). Approval and conditions for Brewer Gold Company application to modify permit 671 (construct new pad 5A).

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1989b (October 23). Approval and conditions for Brewer Gold Company application to modify permit 671 (second lift on pads 5 and 5A).

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1989c (November 7). Approval and conditions for Brewer Gold Company application to modify permit 671 (Prepare for construction of pad 6: clearing, grubbing, sediment control, clay removal).

State of South Carolina, Land Resources Commission, Division of Mining and Reclamation. 1989d (December 8). Approval and conditions for Brewer Gold Company application to modify permit no. 671 (construct pad 6).

Steffen Robertson & Kirsten (Colorado) Inc. Undated (1987). "As-Built Report and Plans for the Brewer Gold Project, Chesterfield County, South Carolina." Prepared for Westmont Mining, Inc., and Brewer Gold Company.

Steffen Robertson and Kirsten (U.S.) Inc. 1990 (April). "Interim Rinse and Treatment System Application for Permit to Construct Sewage and Industrial Waste Treatment System, Brewer Project, Chesterfield County, South Carolina." Prepared for Brewer Gold Company.

U.S. Environmental Protection Agency, Region IV. 1990. Administrative Order (EPA Docket 91-06-C). Issued to Brewer Gold Mine (following October 1990 dam failure)

APPENDIX 2-A

COMMENTS SUBMITTED BY BREWER GOLD COMPANY ON DRAFT SITE VISIT REPORT

[Comments not reproduced for this electronic draft. Copies may be obtained from U.S. EPA, Office of Solid Wastes, Special Waste Branch.]

APPENDIX 2-B

COMMENTS SUBMITTED BY SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL ON DRAFT SITE VISIT REPORT

[Comments not reproduced for this electronic draft. Copies may be obtained from U.S. EPA, Office of Solid Wastes, Special Waste Branch.]

APPENDIX 2-C

COMMENTS SUBMITTED BY
SOUTH CAROLINA LAND RESOURCES COMMISSION
ON DRAFT SITE VISIT REPORT

[Comments not reproduced for this electronic draft. Copies may be obtained from U.S. EPA, Office of Solid Wastes, Special Waste Branch.]

APPENDIX 2-D

EPA RESPONSES TO BREWER GOLD COMPANY COMMENTS ON DRAFT SITE VISIT REPORT

EPA Response to Brewer Gold Company's
Comments on Draft Site Visit Report

Comment: Brewer, in its February 11, 1992, comments (see Appendix 2-A), stated that the report's inclusion (on pages 49 and 50 of the draft report, pages 52 and 53 of the present report) of violations listed in the April 9, 1991, Notice of Enforcement Conference gave a misleading impression of the company's operations and compliance record. Brewer indicated that the resolution of the issues on June 6, 1991 [in Consent Order 91-30-W] was not mentioned in the draft report and that some of the listed violations were without basis, were cleared up once miscommunications were discovered, or the intent on Brewer's part to protect the environment were made clear. Brewer requested that the list of violations be deleted.

Response: EPA believes the list of violations alleged in the Notice is relevant, since a finding of the Consent Order was that violations had occurred "on several occasions." However, EPA notes that the Consent Order did not cite any specific violations. As a result, EPA has deleted the discussion of the Notice and the Order from the report.

APPENDIX 2-E

EPA RESPONSE TO COMMENTS SUBMITTED BY SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL AND SOUTH CAROLINA LAND RESOURCES COMMISSION ON DRAFT SITE VISIT REPORT

EPA Response to Comments Submitted by
South Carolina Department of Health and Environmental Control
and South Carolina Land Resources Commission
on Draft Site Visit Report

EPA has revised the report to incorporate all of the comments submitted by DHEC (see Appendix 2-B) and LRC (see Appendix 2-C). In some cases, EPA made minor changes to wording suggested by DHEC and/or LRC in order to attribute the changes to the State or to enhance clarity.

MINE SITE VISIT:

COLOSSEUM MINE

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street SW
Washington, DC 20460

3.0 SITE VISIT REPORT: COLOSSEUM MINE

3.1 INTRODUCTION

3.1.1 Background

The Environmental Protection Agency (EPA) is assisting states to improve their mining programs. As part of this ongoing effort, EPA is gathering data related to waste generation and management practices by conducting site visits to mine sites. As one of several site visits, EPA visited Colosseum Mine near Las Vegas, Nevada, May 7, 1992.

Sites to be visited were selected to represent both an array of mining industry sectors and different regional geographies. All site visits have been conducted pursuant to RCRA Sections 3001 and 3007 information collection authorities (see Appendix 3-A). When sites have been on Federal land, EPA has invited representatives of the land management agencies (Forest Service and/or Bureau of Land Management). State agency representatives and EPA regional personnel have also been invited to participate in each site visit.

For each site, EPA has collected waste generation and management information using a three-step approach: (1) contacting the facility by telephone to get initial information, (2) contacting State regulatory agencies by telephone to get further information, and (3) conducting the actual site visit. Information collected prior to the site visit is then reviewed and confirmed during the site visit.

In preparing this report, EPA collected information from a variety of sources, including, Colosseum, Inc. and the Bureau of Land Management (BLM). The following individuals participated in the Colosseum Mine site visit on May 7, 1992:

<u>Colosseum Mine</u>

John Trimble, General Manager	(702) 367-3883
Paul Nordstrom, Technical Services Coordinator	(702) 367-3883
Lynn Holden, Chief Metallurgist	(702) 367-3883
Larry Pawlosky, Mine Superintendent	(702) 367-3883

<u>U.S. EPA</u>

Van Housman, Chemical Engineer	(703) 308-8419
Patti Whiting, Environmental Protection Specialist	(703) 388-8421
Haile Mariam, Chemical Engineer	(703) 308-8439
Lisa Jones, Chemical Engineer	(703) 308-8451
Anita Cummings, Environmental Protection Specialist	(703) 308-8303

Science Applications International Corporation

Ingrid Rosencrantz, Environmental Scientist	(703) 734-2508
Laurie Lamb, Geologist	(303) 292-2074

Bureau of Land Management

Bill Wiley, Environmental Protection Specialist	(619) 326-3896
Robert Waiwook, Mineral Examiner	(714) 697-5300

California State Water Resources Control Board

Rick Humphreys, Geologist	(916) 739-4254
Bud Eagle, Geologist	(916) 739-4194

Participants in the site visit were provided an opportunity to comment on a draft of this report. Colosseum Inc. submitted comments, which are presented in Appendix 3-A. EPA responses to comments by Colosseum are presented in Appendix 3-B.

3.1.2 General Facility Description

Colosseum Inc., a subsidiary of Lac Minerals Ltd., conducted mining and cyanide (carbon-in-pulp) leaching of gold/silver ore in the Clark Mountain Range of southeastern California from 1988 to 1993 (see Figure 3-1

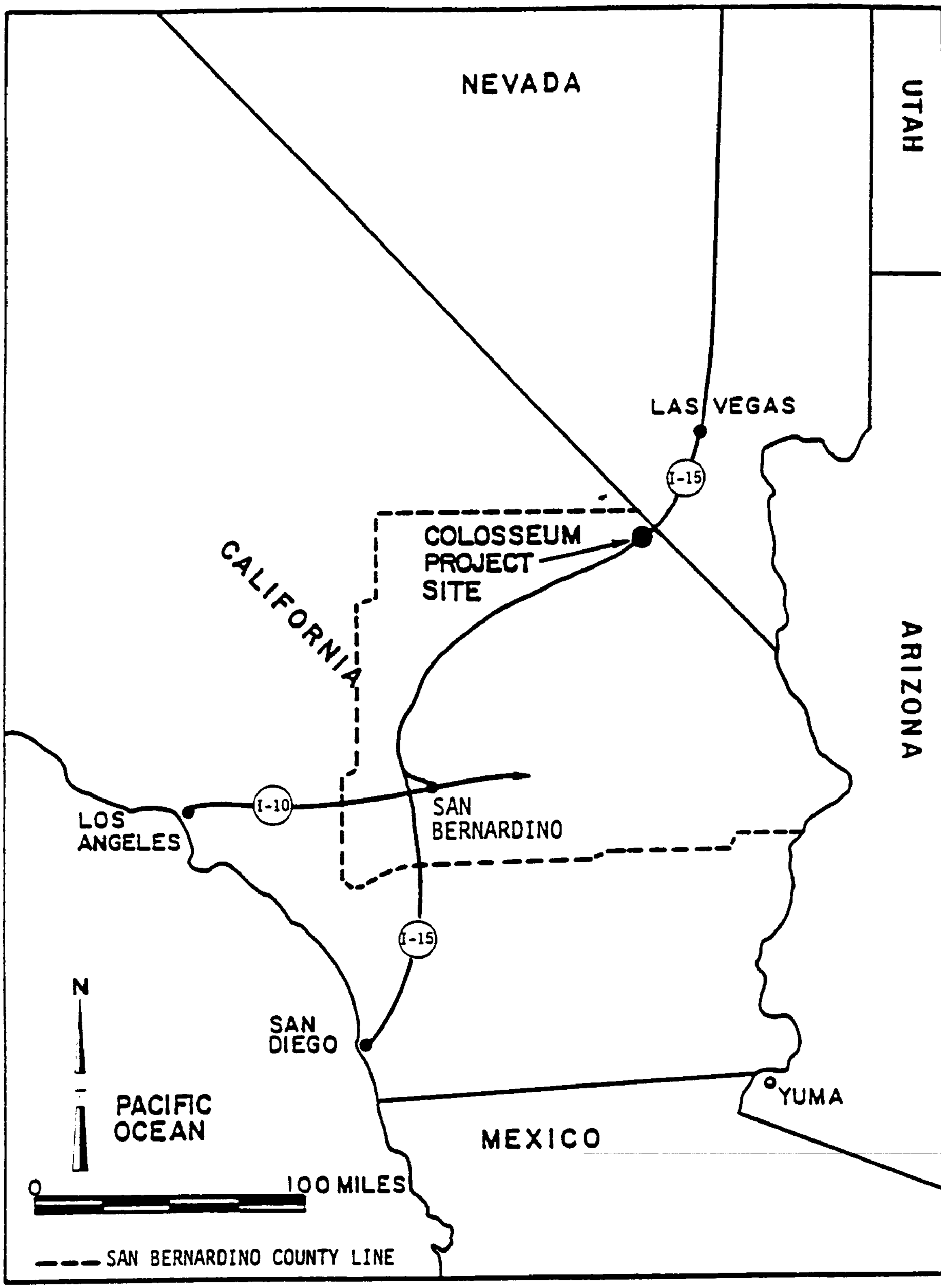

Figure 3-1. Location of Colosseum Mine

(Source: Bureau of Land Management, et al., 1985a)

). Mining operations ceased on July 10, 1992. Milling operations continued until May 1993. The mine and mill are located in San Bernardino County, California, approximately 50 miles southwest of Las Vegas, Nevada. The closest developed area to the mine (12 miles) is Whiskey Pete's, Nevada, a roadside development of casinos, gas stations and fast food restaurants on Interstate 15 at the Nevada/California state line.

The mining facilities occupy 284 acres with another 3,316 acres held as private land and unpatented mining claims. Mining was conducted in two open pits, the South Pit and the North Pit. Most of the mining facility lies on unpatented Federal land under the jurisdiction of the Bureau of Land Management (BLM); but two patented claims are located in the South Pit. Land use in the vicinity of the mine includes grazing and recreation. A large BLM grazing lease overlaps the mine/mill/tailings complex. The mine is located within the boundaries of the East Mojave National Scenic Area and the Clark Mountain Area of Critical Environmental Concern. These areas provide for limited multiple use of public lands within their boundaries. In addition, one Wilderness Study Area borders the property held by Colosseum Inc. (Bureau of Land Management, et al., 1985a)

The mine is within the old Clark Mountain Mining District, which produced silver, gold, copper, lead, tungsten and fluorite at various times over the last 120 years. Gold was first produced in the district in the 1930s. In the 1970s, Draco Mines and their partners performed intermittent exploration drilling on the Colosseum property. Amselco leased the property from Draco Mines in 1982 and conducted extensive drilling and feasibility studies between 1982 and 1984. Amselco began the required permit applications in 1983 and a Final Environmental Impact Report and Environmental Impact Statement was approved in July 1985 (see section 3.4.1).

Dallhold Resources, Inc., purchased the Colosseum property in September 1986. Sometime after this purchase, Dallhold Resources, Inc., became part of Bond International Gold, Inc. Mine and mill construction began in 1987 and the mill began operation in January 1988. In November 1989, the Colosseum Mine changed ownership once more when Lac Minerals, Ltd., acquired the mine through their purchase of Bond International Gold, Inc.'s properties. Colosseum, Inc., a subsidiary of Lac Minerals Ltd., operated the Colosseum mine until July 10, 1993. (Attaway, Undated; Bond Gold Colosseum, Inc., 1990; Holden, H.L. 1991)

The mill was active seven days a week, twenty-four hours a day and the open pits were mined Monday through Friday, nine hours a day. On average, the mine employed 110 people, with peak employment of 300 during the construction of the facilities in 1987. The mine employed 94 people in May 1992: 55 employees of Colosseum Inc. and 39 employees of the contract mining company, Industrial Contractors Corporation.

In 1990, total reserves were estimated at 3.9 million tons of ore with an average grade of 0.040 troy ounces of gold per ton. As of July 12, 1990, Colosseum had produced over 170,000 troy ounces of gold. (Bond Gold Colosseum, 1990b).

On July 10, 1992, Colosseum ceased mining after four and one-half years of operation. Milling of stockpiled ore continued until May of 1993. According to Colosseum personnel, there are no plans to continue mining due to a variety of economic reasons. Reclamation has been ongoing. (Colosseum Inc., 1992e)

3.1.3 Environmental Setting

The Colosseum Mine lies in the southern end of the Great Basin Physiographic Province in the Clark Mountain Range (see Figure 3-2

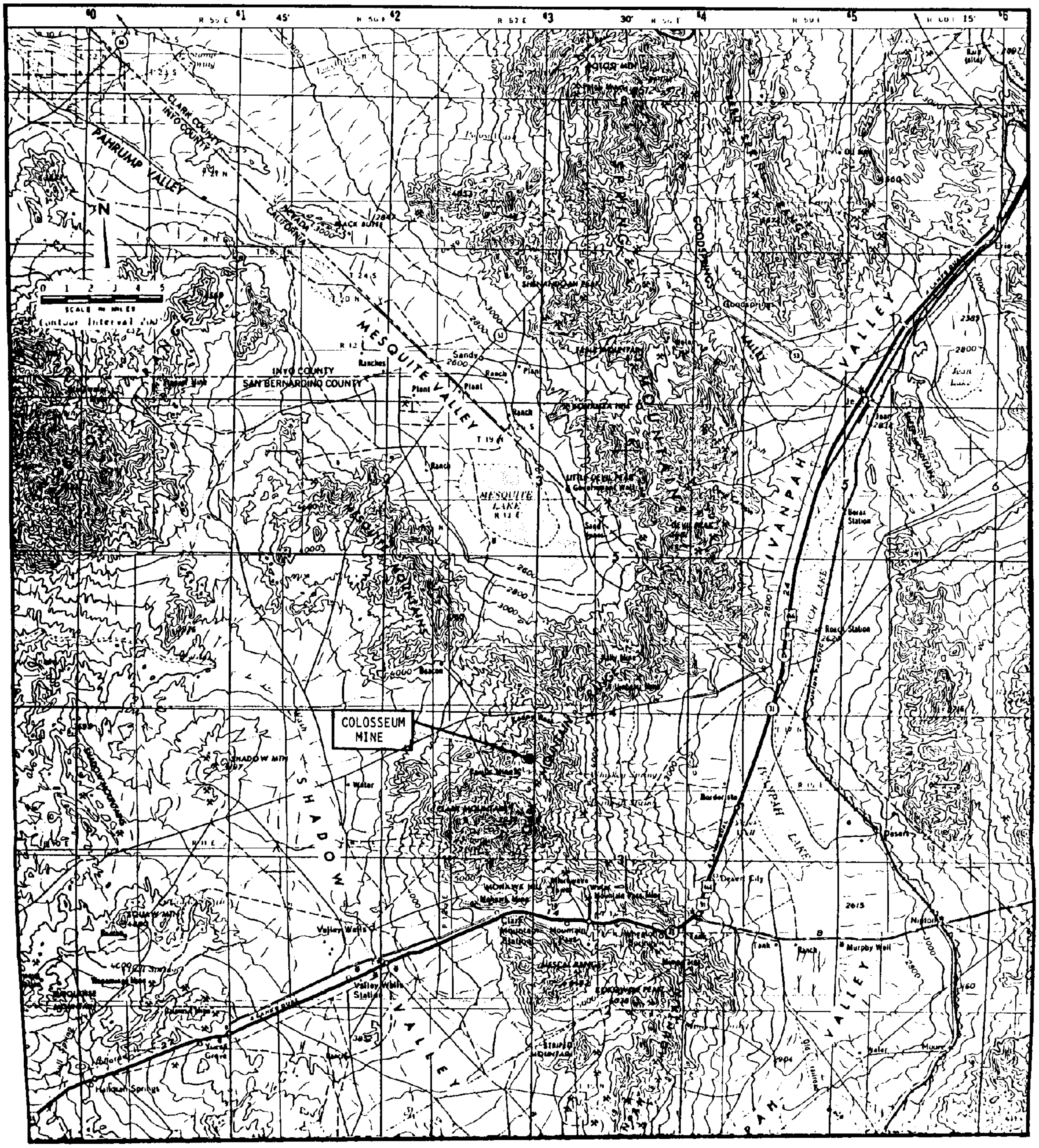

Figure 3-2. Topographic Setting of the Colosseum Mine

(Source: Bureau of Land Management, et al., 1985a)

). The Great Basin Province is characterized by valley and range topography that resulted from block faulting during Tertiary time. The Clark Mountains reflect this topographic expression, being bounded by Ivanpah Valley on the east, Shadow Valley on the west and Mesquite Valley to the north.

The mine is located between 5,000 and 6,000 feet above sea level on the northeast side of Clark Mountain, the highest peak in the range at 7,929 feet above sea level. The mine and mill buildings occupy the northern end of a gently sloping plateau-like area, which extends from the north flank of Clark Mountain to the two open pits. Colosseum Gorge dissects the northern end of this plateau-like area to the east and an unnamed dry wash dissects the area on the west.

The climate is that of a high, mid-latitude desert, characterized by very low precipitation and large diurnal temperature fluctuations. Annual precipitation (virtually all in the form of rain) at Mountain Pass, approximately six miles south-southeast of the mine site and at a higher elevation, averages between 10 and 12 inches. Most of the precipitation falls during November and December as frontal winter storms pass over the mountains and in the spring and summer from convectional thunderstorms. According to Colosseum personnel, since the start of mining, precipitation has averaged less than seven inches per year (as measured by a rain gauge at the mine). As of May 1992, the mine had received slightly less than six inches of precipitation for the year.

Temperatures in the region experience large ranges due to the efficient heating and cooling of the earth under the generally clear skies. As of 1980, the mean maximum temperature at Mountain Pass was 85.8 degrees Fahrenheit ($^\circ$F) and the mean daily minimum temperature was 46.1°F. Prevailing winds at the mine are from the northwest, with significant southerly flows. Diurnal wind data indicates a typical up- valley/down-valley pattern of air movement. During the day, warming air in the valleys rises up the drainages, and through the late night and early morning, cooled air travels back down the drainages.

Habitat for the Desert Tortoise (a Federal endangered species) exists in Ivanpah Valley, along the main access road to the mine. In addition to the road, the other main disturbance to the Desert Tortoise habitat is a fresh water pipeline that carries water from supply wells in the valley to the mine. Speed controls, elevated pipelines and regular sweeps of the road have been implemented by Colosseum through their operating permit to protect the Desert Tortoises living in Ivanpah Valley (see section 3.4).

3.1.4 Geology

Igneous and sedimentary rocks of Precambrian and Paleozoic age form the structurally complex Clark Mountain Range. The mine lies in the Clark Mountains between two major faults: to the west of the mine is the north-northwest trending Clark Mountain thrust fault and to the east is the high-angle Ivanpah normal fault, which extends northwest-southeast through Ivanpah Valley (see Figure 3-3

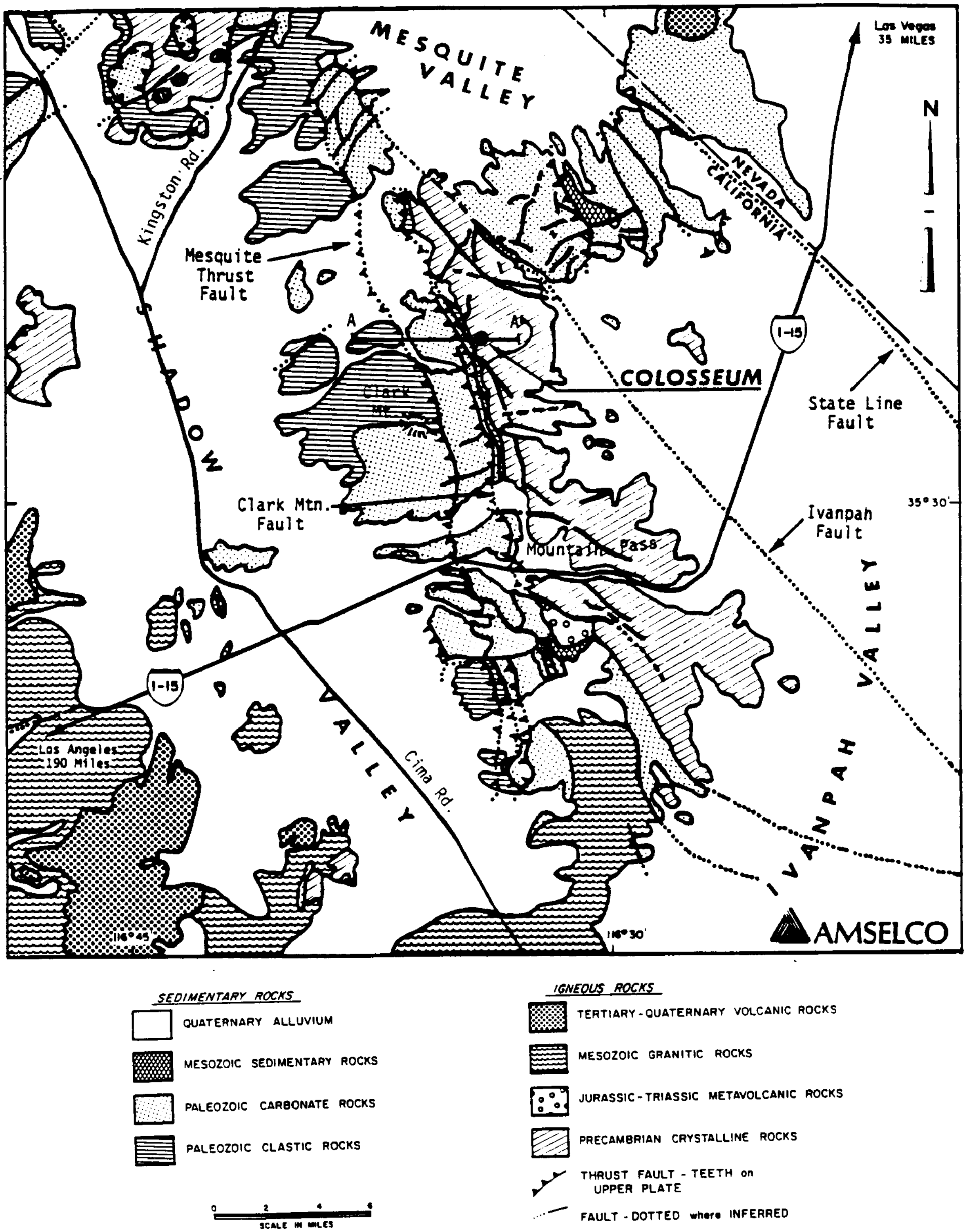

Figure 3-3. Colosseum Site Geology

(Source: Bureau of Land Management, et al., 1985a)

The Clark Mountain thrust fault creates an unconformity between Precambrian granitic gneiss to the east of the fault and Cambrian sedimentary rocks to the west of the fault. (Bureau of Land Management, et al., 1985a)

The ore body mined by Colosseum consists of two small mineralized felsite breccia pipes (north and south) intruded into the Precambrian granite gneisses. The breccia pipes are estimated to be 100 million years old (mid to late Cretaceous). Each breccia pipe is approximately 500 feet x 300 feet wide and extends to over 1500 feet deep.

A felsite breccia dike connects the two pipes. The emplacement and mineralization of the pipes is thought to have occurred through the intrusion of rhyolite bodies followed by multiple explosive hydrothermal fluid movements. (Bond Gold Colosseum, Inc, 1990; McClure, 1988)

Most of the mine facilities are located on soils weathered from Precambrian crystalline rocks. The contact between the Precambrian crystalline rocks and the Cambrian sedimentary rocks is just west of the mine buildings, near the tailings impoundment. Thin and discontinuous alluvial deposits are found in drainages around the facility area.

Two wells (MW1 and MW3, see section 3.3.2) drilled downgradient of the tailings impoundment intersect Cambrian sedimentary rocks after drilling through alluvial materials (Sergent, et al., Undated). One well intersects the Cambrian rocks at three feet below the ground surface and the other at 90 feet below ground surface. This 87 foot offset may suggest that a high angle fault extends between the two closely spaced wells. According to Colosseum, the difference in Cambrian contact elevation may simply be the result of stream erosion.

The gold mineralization in the breccia pipes is submicroscopic and occurs with silver in close association with pyrite (the ratio of gold to silver is 1:1). Gold occurs in contact with pyrite, in pyrite fractures, along pyrite grain edges, and encased in pyrite crystals. A low percentage (around 15 percent) of silver is found with the gold as electrum, a natural alloy; the rest is believed to be present in silver minerals (McClure, 1988). Other metals found in the ore include lead, zinc, copper, arsenic, and mercury. According to Colosseum personnel, very little mercury is found in the ore. The two pipes have been mined in two separate open pits: the North Pit with an average grade of 0.04 troy ounce of gold per ton and the South Pit with an average grade of .067 troy ounce of gold per ton.

Recent history indicates that the Colosseum Mine is located in an area of relatively minor seismic activity. From 1932 through 1977, no earthquakes of Richter Magnitude 4 or greater were recorded within a 50 mile radius of the mine. However, for the design of the tailings impoundment, seismic studies were conducted to determine the Maximum Credible Earthquake (MCE). The MCE was determined to occur along the Ivanpah Fault (see Figure 3-3) at Richter Magnitude 6.0. (Bureau of Land Management, et al., 1985a)

3.1.5 Surface Water

No perennial streams exist in the vicinity of the Clark Mountains. During the site visit, the EPA team observed no water in the ephemeral channels at the site. Information on when and how much water is conveyed in these drainages was not obtained. Springs in the Colosseum Gorge support intermittent streams and watering holes southeast of the mine along the Old Gorge road. According to Colosseum, all of the haul roads, pits, and mill area drain to the tailings impoundment. Other mine areas, including the waste rock piles drain directly to Shadow Valley.

3.1.6 Ground Water

According to the EIS, hydrogeologic studies (author unknown) at the mine site suggest that ground water resources are limited, existing primarily in fractured bedrock (Precambrian gneiss). However, regional ground-water systems exist in the valleys surrounding the Clark Mountain Range: Ivanpah, Shadow and Mesquite Valleys. These ground-water systems are at least ten miles from the mine and are at elevations approximately 2,000 to 3,000 feet below the mine. Recharge to these systems occurs through direct precipitation and runoff from the surrounding mountains (including the Clark Mountains). (Bureau of Land Management, 1985a)

Ground water exists in fractured Precambrian gneiss at the mine site. According to Colosseum, five (of nine) site monitoring wells contain water. Green's well, an old livestock watering well now beneath the tailings impoundment, also contained water. All of these wells were completed in bedrock. Depth to water in these wells (total depth of wells was not available) ranges between 14 and 67 feet below ground surface. Green's well and mine shafts (see Section 3.3.2 for further discussions), located in the middle of the tailings impoundment, were estimated as over 350 feet deep and as containing ground water at a depth of 55 feet below ground surface (Bureau of Land Management, 1985a).

The gneisses are of low permeability: field tests indicate hydraulic conductivity ranges from 3×10^{-7} to 9×10^{-6} centimeters per second. Transmissivity calculated from results of aquifer tests ranged from 24 to 52 gallons per day per foot. According to the EIS, these very low values indicate groundwater exists in the fractured bedrock, but that existing water flows at very low velocity and is subject to very little recharge from surface runoff (exact data on recharge were not provided in the EIS). Baseline geologic and hydrogeologic studies completed prior to the approval of the mine state that these aquifer properties limit the vertical or lateral hydraulic connection that may exist between the site ground-water resources and the regional ground water systems existing in the valleys (Bureau of Land Management, 1985a). These baseline studies were not obtained for review and analysis in this report.

Two wells, MW1 and MW3, drilled into the sedimentary Cambrian units downgradient of the current tailings impoundment, were found to be dry. It is unclear if the Cambrian units may contain water in other areas surrounding the facility. According to Colosseum personnel, further information on these wells is not available.

It is unclear if water resources exist in small pockets of alluvium at the site. With the exception of monitoring well MW2, a dry well installed downgradient of the tailings impoundment, no information was obtained on wells that may have been completed in the limited alluvial deposits (see section 3.3.2).

Several springs, both perennial and intermittent, exist in the Colosseum Gorge, just east of the site. Water quality of these springs is good; TDS concentration is approximately 550 mg/l. The springs yield only small amounts of water, ranging from 0.1 - 5.0 gpm; however, as discussed above, they provide sufficient water tosupport intermittent streams and watering holes in the Colosseum Gorge. (Bureau of Land Management, et al., 1985a) Figure 3-4, a topographic map of limited extent, shows the location of several ground-water wells

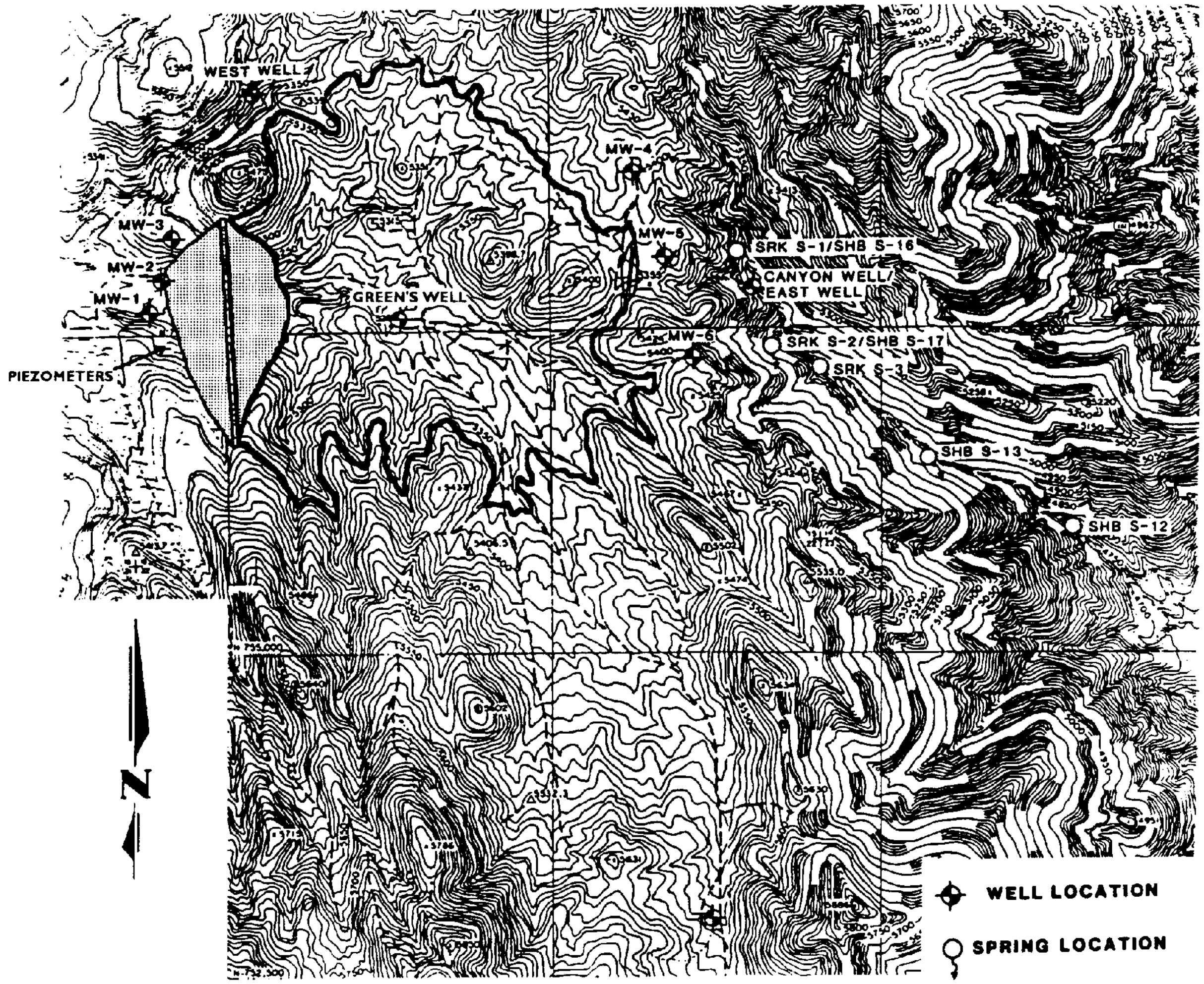

Figure 3-4. Locations of Wells and Springs Near the Tailings Impoundment and in Colosseum Gorge

(Source: Steffen Robertson and Kirsten, 1987)

Table 3-1. Concentrations of Selected Constituents from Quarterly Samples of Ground Water Extracted From the Ivanpah Valley Aquifer

Analyte	1988* Min. - Max.	1989 Min. - Max.	1990 Min. - Max.	1991** Min.- Max.
Conductivity, mmhos/cm	697 - 709	678 - 709	666 - 741	653 - 769
pH, s.u.	8.0 - 8.10	8.08 - 8.19	7.80 - 8.13	8.16- 8.48
WAD CN, ppm	<0.005 - <0.02	<0.02	<0.02	<0.02
Total CN, ppm	<0.005 - <0.02	<0.02	<0.02	<0.02
TDS, ppm	313 - 350	325 - 340	330 - 360	350 - 360
Sulfate, ppm	37 - 47	45 - 46	35 - 45	43 - 47
Sodium, ppm	47 - 57	48 - 59	55 - 63	59 - 63
Copper, ppm	<0.01 - <0.02	<0.02	<0.02	<0.02
Iron, ppm	0.05 - <0.02	0.05 - <0.01	<0.01	<0.01 - <0.04
Zinc, ppm	0.18 - 0.37	0.05 - 0.17	0.03 - 0.1	0.02 - 0.9
Lead, ppm	NS	<0.002	<0.002	<0.002

KEY:
* 1988 data is for only two sampling events (two quarters).
** 1989 data is for only three sampling events (three quarters).
NS - No sample

Source: Colosseum, Inc., 1992.

and springs.

As discussed above, there are aquifers in the valley surrounding the site. The Ivanpah Valley Aquifer ranges from 20 to 220 feet below the surface of the valley. The total aquifer storage capacity has been estimated by the California Department of Water Resources at 3,090,00 acre-feet, with an annual recharge of approximately 800 acre-feet. According to the EIS, when the mine was originally proposed, the Ivanpah Valley Aquifer was experiencing diminishing ground water levels, or "overdrafts", as a result of annual ground-water extractions exceeding the annual recharge. Colosseum maintains two wells in the Ivanpah Valley for water supply. These wells provide 800 gallons per minute, 16 hours a day (i.e., approximately 860 acre-feet per year). Consequently, ground water extraction for Colosseum's operations may result in further ground water overdrafts in the Ivanpah Valley Aquifer. Water quality of ground water in the aquifer is highly variable, ranging from good to poor, and has been used in industrial, irrigation, domestic, and livestock operations. Colosseum samples and analyzes the ground water extracted from their Ivanpah Valley Aquifer water supply wells on a quarterly basis. Samples are collected at building taps. Table 3-1 presents a summary of this water quality data.

The Shadow Valley Aquifer ranges in depth from 40-300 feet below ground surface. Total storage capacity was estimated by the California Department of Water Resources as 2,130,000 acre-feet. Ground water quality in the Shallow Valley aquifer is highly variable, with TDS values ranging from 500 - 2,400 mg/l and poor quality water exiting from the local valley springs. During operations, Colosseum extracted no water from the Shadow Valley Aquifer.

Depth to the Mesquite Valley Aquifer ranges from 20 to 200 feet. The California Department of Water Resources estimated the aquifer storage capacity at 580,000 acre-feet. The water quality is locally unsuitable for domestic and irrigation uses. During operations, Colosseum extracted no water from the Mesquite Valley Aquifer.

3.2 FACILITY OPERATIONS

This section describes the extraction and beneficiation operations as they appeared during the time of EPA's site visit at the Colosseum Mine in May of 1992. Since that time both the mine and mill have ceased operation. During operation, the flow of materials began with the removal of waste rock and ore from two open pits. The ore was either transported to the mill or stored in the low grade stockpile. At the mill, the ore was crushed, ground and leached in a Carbon-In-Pulp (CIP) cyanide circuit for the removal of precious metals. After stripping the precious metals from the carbon, electrowinning, electrorefining and smelting (in a small furnace), a doré of 70 percent gold and 30 percent silver was produced. A general site map illustrates the location of facilities described below (see Figure 3-5

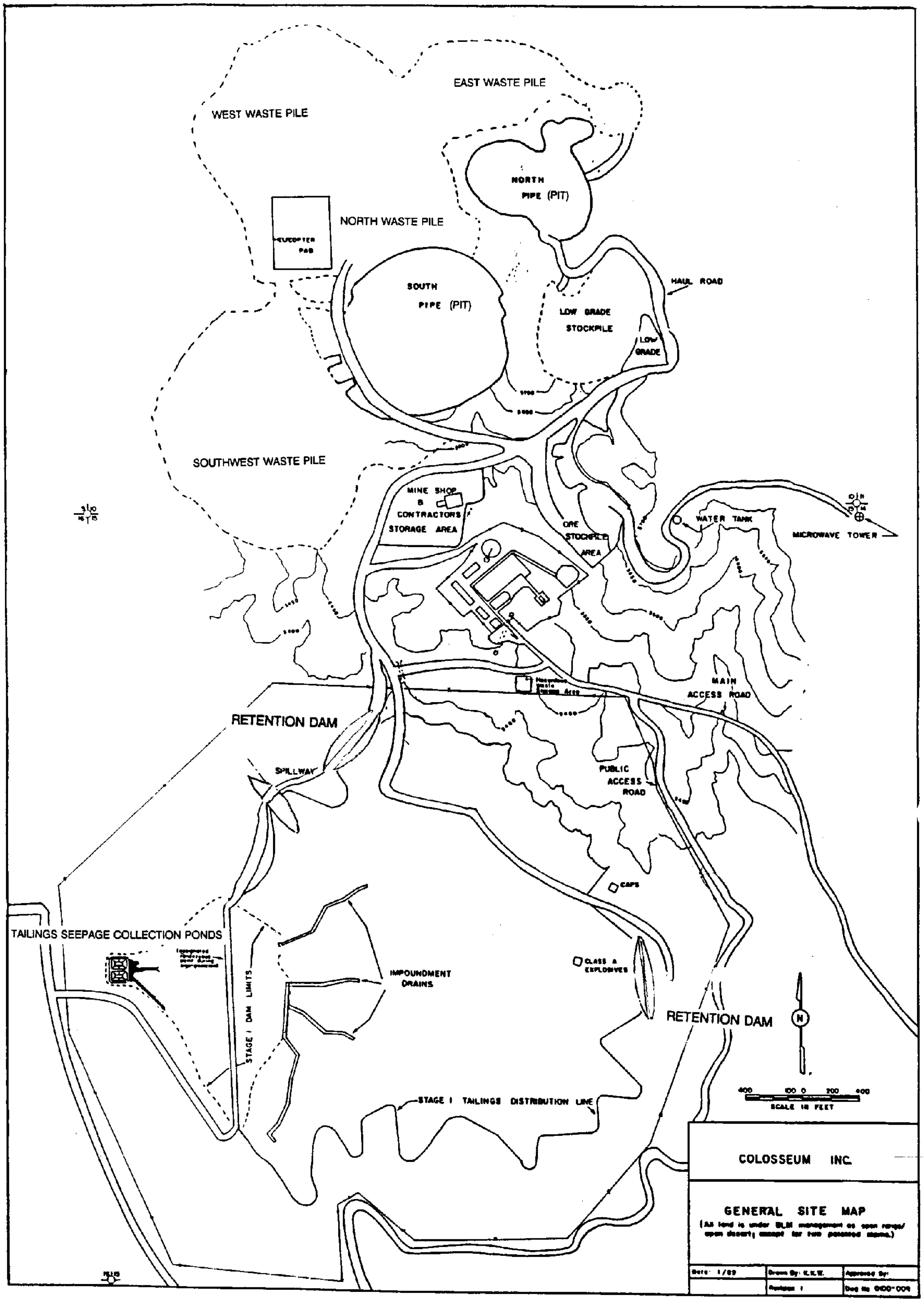

Figure 3-5. General Site Map of the Colosseum Mine

(Source: Colosseum, Inc., 1989a)

3.2.1 Mining

Mining began at Colosseum in late 1987 and the mill began operating in January 1988. In May 1992, mining at the Colosseum Mine removed 15,000 tons of rock per day, five days a week. This rate was down from the 29,000 tons of rock removed per day, six days a week in 1990. The State permitted the mine to excavate up to 31,000 tons per day. (Attaway, Undated)

The two breccia pipes (ore bodies) were mined through two open pit excavations: the North and South pits. Colosseum used a contract mining company, Industrial Contractors Corporation, to drill, blast, excavate and transport the waste rock and ore from the pits. Blastholes with a 6.5 inch-diameter were drilled on a 15-foot by 15-foot square pattern using a downhole hammer. ANFO (ammonium nitrate mixed with fuel oil) was used as the blasting agent. Four blasts were conducted each week, with no more than one per day. A 13-cubic yard front-end loader excavated the broken rock and placed it into 85-ton haulage trucks for transport to either the waste rock piles, the low-grade stockpile (the waste rock /low-grade cutoff was not obtained), or the primary crusher. Fifty-ton haulage trucks were used in the South Pit due to the restricted access of the narrowed pit configuration at the bottom of the pit (see section 3.3.3).

According to Colosseum, the project to date stripping ratio in both pits was 3.97:1 (waste to ore). In the South Pit, Colosseum maintained a 2:1 (waste to ore) stripping ratio. Colosseum reported a 6:1 stripping ratio on some 20 benches in the South Pit (it is unclear how this ratio relates to the overall South Pit ratio of 2:1). The stripping ratio in the North Pit was 1:1 (waste:ore). The interslope angle of the South Pit is 53 degrees. The interslope angle of the North Pit is 45 degrees. Twenty-foot benches were maintained in both pits. Safety benches were left every 60 feet in the South Pit and every 40 feet in the North Pit.

At the time of EPA's visit, the bottom of the South Pit was at an elevation of 5280 feet, approximately 760 feet deep. Colosseum personnel estimated that continued mining in the South Pit will result in a finished elevation of 5240 feet for the bottom of the South Pit. The mine superintendent estimated the greatest distance across the South Pit to be 1600 feet. The EPA team observed water in the bottom of the pit. According to Colosseum personnel, water is pumped to the tailings impoundment from a sump in the bottom of the pit (no estimate was provided on the amount of water encountered or the level at which water was first encountered). Ore removed from the South Pit yielded approximately 80 ounces of gold per day (when higher grade ore was mined, yields were up to approximately 200 ounces of gold per day). Mining in this pit was scheduled to end in June 1992.

The North Pit bottom was at an elevation of 5,740 feet with a depth of 300 feet at the time of EPA's visit. Prior to 1991, the North Pit was used mostly as a "relief area," mined when the South Pit was being drilled and blasted. In 1991, heavy mining began in the North Pit. According to Colosseum personnel, ore removed from the North Pit yielded 40 to 60 ounces of gold per day. During the site visit, Colosseum personnel estimated that mining would cease in the North Pit at the end of August 1992. On August 4, 1992, Colosseum notified EPA that mining had terminated in both pits on July 10, 1992.

3.2.2 Beneficiation

The beneficiation plant is designed for an ore throughput of 3,400 tons per day, or 1.2 million tons per year. As of May 1992, the circuit was beneficiating 3,000 tons of ore per day. Milling operations ceased on May 31, 1993. Figure 3-6 presents a map of the mill. Figure 3-7

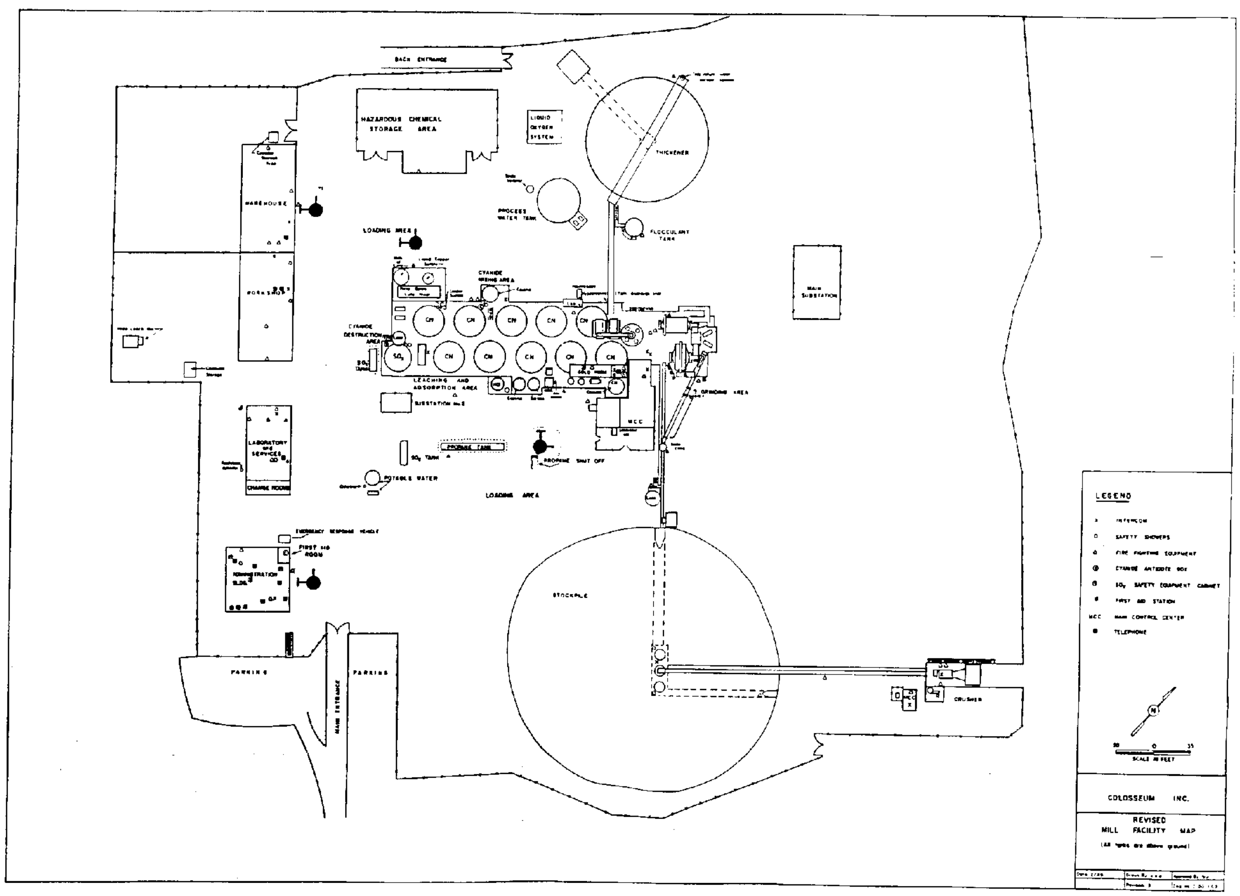

Figure 3-6. Colosseum Mill Facility Map

(Source: Colosseum, Inc., 1989b)

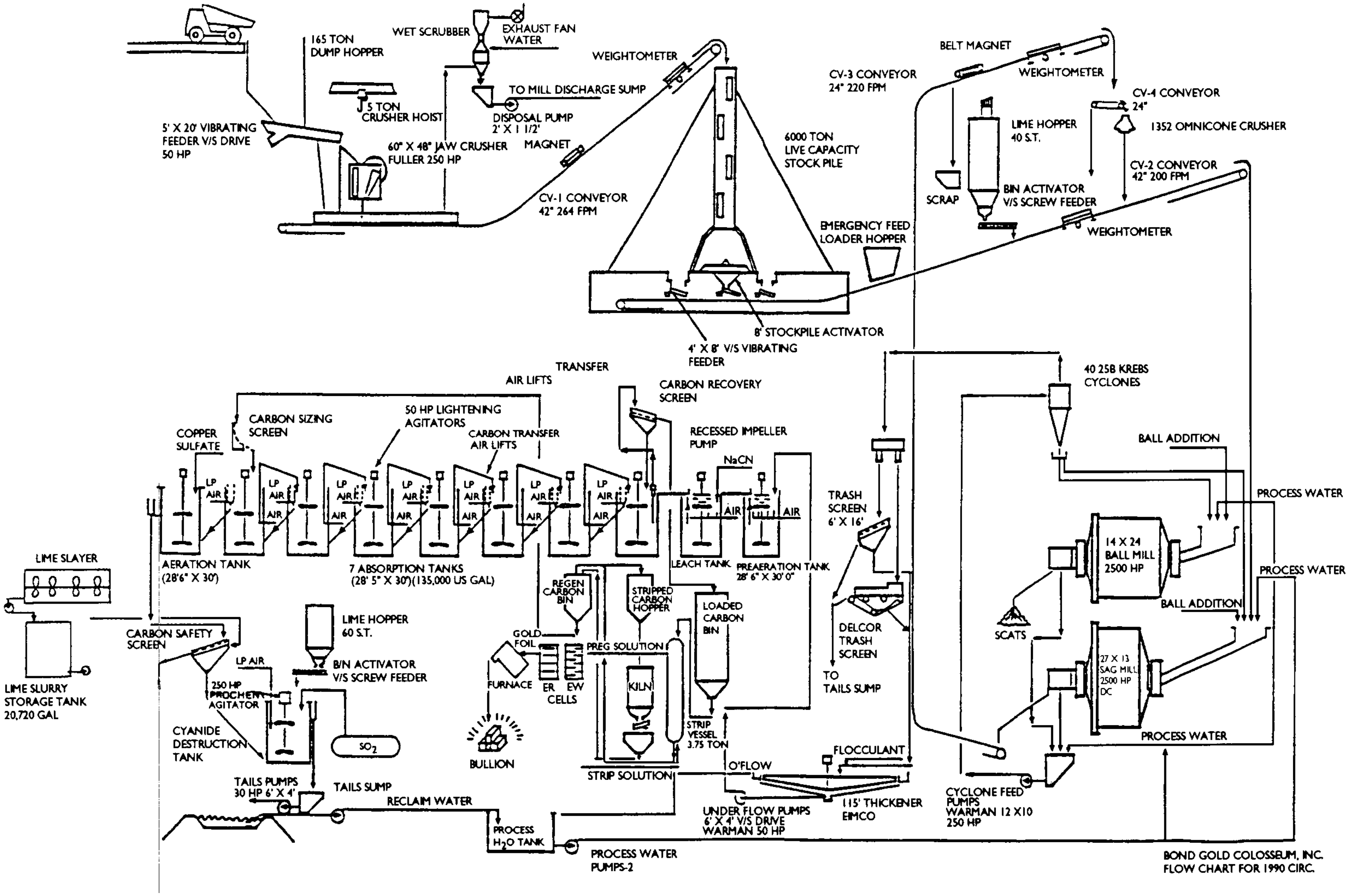

Figure 3-7. Colosseum Mill Flow Chart

(Source: Bond Gold Colosseum, Inc., Undated) illustrates the flow of ore and materials through the entire beneficiation operation.

3.2.2.1 Crushing and Grinding

Ore is dumped out of the haulage trucks into a 185-ton hopper with a vibrating feeder. Oversize material (greater than 6-inch) goes to the swing jaw crusher (48 inch by 60 inch) and undersize material (minus 6-inch) goes to a conveyor for transport to the crushed ore stockpile. The jaw crusher reduces the ore from a size of up to 3 feet to less than 6 inches. The crushed ore drops onto the conveyor for transport to the crushed ore storage pile. The crushed ore stockpile contains a 10-day supply for the Carbon-In-Pulp (CIP) plant, with a total capacity of 33,000 tons.

Water sprays are used to control dust at the 185-ton hopper when haulage trucks are dumping ore. The ore crushing unit (including the vibrating feeder, the jaw crusher, the conveyors and the feeders) is equipped with a wet scrubber to collect dust. Slurry from the wet scrubber is pumped to the common mill discharge sump for mixing with the ore slurry. During EPA's visit, the jaw crusher was not operating due to sampling of the wet scrubber. According to Colosseum, the testing of the wet scrubber was for particulate emissions levels and for lead concentrations in the emissions.

Three feeders beneath the stockpile convey ore at the rate of 150 tons per hour to the semi-autogenous grinding (SAG) mill. As the ore is conveyed to the SAG mill, it passes under a lime silo where lime is added to the ore at the rate of two pounds per ton. The purpose of the lime addition is to maintain a pH of 10.8 in the leach circuit. A baghouse is used to collect lime particulate emissions from the lime silo. The conveyor and grinding equipment are equipped with exhaust venting to a wet scrubber. All storm water runoff from the pile and the immediate mill area is directed to the tailings impoundment.

The SAG mill is rubber-lined and measures 21 feet by 13 feet. Water and ore are continuously added to the SAG mill during operation. Grinding media, five-inch steel balls, are charged to the SAG mill daily. The SAG mill grinds the ore to approximately 3/4-inch and maintains 70 percent solids by weight in the discharge slurry. The slurry exiting the SAG mill passes over a grate for the removal of resistant pebbles. These pebbles are sent to a cone crusher for crushing with the crushed product being conveyed back to the SAG mill.

The slurry passing through the grate enters the common mill sump where additional water is added. The slurry is then pumped to a cyclone for sizing. Oversized material (greater than 80 mesh) is sent to a 14- by 24-foot ball mill for additional grinding. The ball mill grinding media are abraded balls from the SAG mill, typically two to three-inches in diameter, and new three inch balls. The ball mill discharge slurry is about 76 percent solids by weight. In the ball mill, ore is ground so that 100 percent passes minus 80 mesh (the feed size for the CIP) and 80 percent passes 120 mesh before it exits the ball mill into the common mill sump. The slurry in the common mill sump is pumped to the cyclone for sizing. Undersized material (approximately 18 percent solids) continues to the CIP, by way of a thickener, and oversize material (i.e., over 120 mesh) is returned to the ball mill for further grinding.

On its way to the thickener, the ore slurry passes over a trash screen, which removes oversized material that has made it through the cyclone sizing operation. This material is typically wood and paper, which makes it through the cyclones because of its low specific gravity. The "trash" is returned to the tailings sump and disposed of as tailings. According to Colosseum, the amount of "trash" is less than 0.01 percent of the tailings. The slurry enters the thickener along with a flocculent, an anionic polymer, A-207. The thickener dewaters the slurry to approximately 56 percent solids by weight. Overflow (water) from the thickener is recycled into the mill makeup water tank and the thickened slurry is typically pumped to a pre-aeration tank (tank 1) to oxidize any sulfides present prior to entering the CIP tanks.

The SAG mill is powered by a 2,500 horsepower direct current variable speed motor for efficient grinding. The Ball mill is powered by a constant speed 2500 horsepower alternating current motor. The grinding units receive maintenance once per week with a complete lubrication. The rubber liners in the SAG mill are replaced every four to six months.

3.2.2.2 Carbon-In-Pulp

Colosseum used the Carbon-In-Pulp technique to leach the precious metals from the ground ore slurry. Ore slurry is pumped to a leach tank where sodium cyanide (NaCN) is added and the slurry is agitated. This cyanide/ore mixture is pumped to the first tank and then gravity flows through a series of tanks for the recovery of the precious metals. Activated carbon is transferred by airlifts through the tanks countercurrent to the flow of the ore/cyanide slurry. Gold and silver cyanide complexes adsorb on the carbon, creating loaded carbon at the front of the circuit. At Colosseum, the circuit maintains a constant ore/cyanide slurry flow of 700 gallons per minute. Tank 1 (130,000 gallon capacity) is normally the first tank in the leach circuit. Compressed air is sparged into the slurry to enhance dissolved oxygen content. The total sulfur content of the ore processed is kept at less than 2.5 percent to limit oxygen consumption. Tank 1 was not in use at the time of EPA's visit due to a change in the sulfide content of the mined ore. During normal operation, slurry from tank 1 gravity flows to tank 2, where 15 percent sodium cyanide (NaCN) is added; tank 2 is agitated. Since tank 1 was not in use during the site visit, tank 2 was the first step in the CIP operation at that time. This tank is sampled every 2 hours and cyanide content is maintained at 0.6 pounds per ton of solution, the optimal concentration for leaching the ore.

There are seven steel CIP tanks, numbered three through nine. The leached slurry is pumped into tank number 3 and leaves through tank 9. At the same time, coarse carbon gravity flows into tank 9 and travels toward tank 3, countercurrent to the slurry flow. Each tank holds 130,000 gallons of ore slurry and six tons of carbon. The carbon is advanced from tank to tank by airlifting the slurry to external screens that discharge the carbon to the preceding tank. Compressed air is bubbled along screens in the tanks to aid circulation by inhibiting screen blinding. The ore slurry gravity flows to the next tank. The ore slurry has a 24-hour residence time for the entire circuit. The gold concentration of the slurry, initially 2.0 to 2.5 ppm in the first tank, drops to less than 0.01 ppm in the final tank as it is adsorbed by the carbon. The spent ore slurry (tailings) gravity flows to an aeration tank, tank 10, for a final screening of any carbon that may have become inadvertently entrained in the spent ore. Tailings, containing approximately 260 ppm weak acid dissociable

(WAD) cyanide, gravity flow from the aeration tank to tank 11 for cyanide destruction using the INCO SO_2 Process (see section 3.3.1). In 1991, 928,444 tons of ore were leached in the CIP circuit.

All tanks in the CIP circuit are surrounded with secondary containment. According to facility personnel, the secondary containment has sufficient capacity to handle "all spills", but the exact volume of secondary containment was not obtained. Any spillage is reportedly pumped back into the process tanks.

3.2.2.3 Carbon Stripping

Loaded carbon containing as much as 120 troy ounces of gold per ton of carbon, is pumped in batches from the CIP tanks to a stripping column. The stripping column is a 20-foot tall, rubber-lined steel tank with a capacity of 3.8 tons. A solution of 1.5 percent cyanide and one percent caustic (sodium hydroxide) is heated to 240°F and circulated in the stripping column (the pH of this solution and its method of heating was not obtained). This stripping solution creates a chemical environment that favors the dissolution of gold from the carbon and the creation of gold cyanide complexes. When the stripping cycle is complete, the pregnant solution, containing approximately 250 ppm gold, is sent to a pregnant solution tank. It is unclear how long the carbon stripping cycle takes to remove the gold/cyanide from the carbon.

At the end of the stripping cycle, the carbon contains four troy ounces of residual gold per ton. A hydrochloric acid solution (concentration of hydrochloric acid was not obtained) is used to clean the carbon before it is regenerated and sent back to the CIP circuit. Carbon fines collected from the regeneration operation are currently stored on-site, but will be sent to an off-site smelter for the recovery of residual precious metals after the mill closes. Approximately 0.035 pounds of carbon per ton of ore leached are lost to attrition. Further information about the disposition of the acidic cleaning solution or the carbon regeneration operation was not obtained.

3.2.2.4 Electrowinning, Electrorefining, and Smelting

The company uses electrowinning to recover the gold from the pregnant solution. Pregnant solution is pumped from the pregnant solution tank to two parallel 32-cubic-foot cells, and circulated at a rate of approximately 20 gallons per minute. As the solution circulates through the electrowinning cells, gold is precipitated onto steel wool. Residence time for the pregnant solution is up to 19 hours or until the gold concentration in the solution falls below 20 ppm. The now barren solution is recycled to tank 2, the leach tank.

The gold-laden steel wool cathodes are transferred from the electrowinning cells to a 32-cubic-foot electrorefining cell containing stainless steel plates and filled with electrolyte containing five percent sodium cyanide and 1.5 percent sodium hydroxide recirculated at 50 gallons per minute. The polarity is reversed and gold on the steel wool is plated onto the stainless steel sheets. Residual gold also accumulates on the bottom of the cell as gold sludge. Gold is scraped from the plates and the bottom of the cell and sent to the furnace for melting. The gold furnace is operated two or three times per week. According to Colosseum, the use of chemicals in the electrorefining operation is according to strict procedures. All spent solutions are recycled or returned to the mill circuit as chemical additions to assist in gold extraction.

The furnace is charged with gold foil and gold sludge, and borax, silica, and potassium nitrate, which are used as a flux. The furnace has an exhaust hood that leads to a high stack operating with no scrubber or emission control device. The furnace is powered by clean burning propane. According to Colosseum, furnace stack

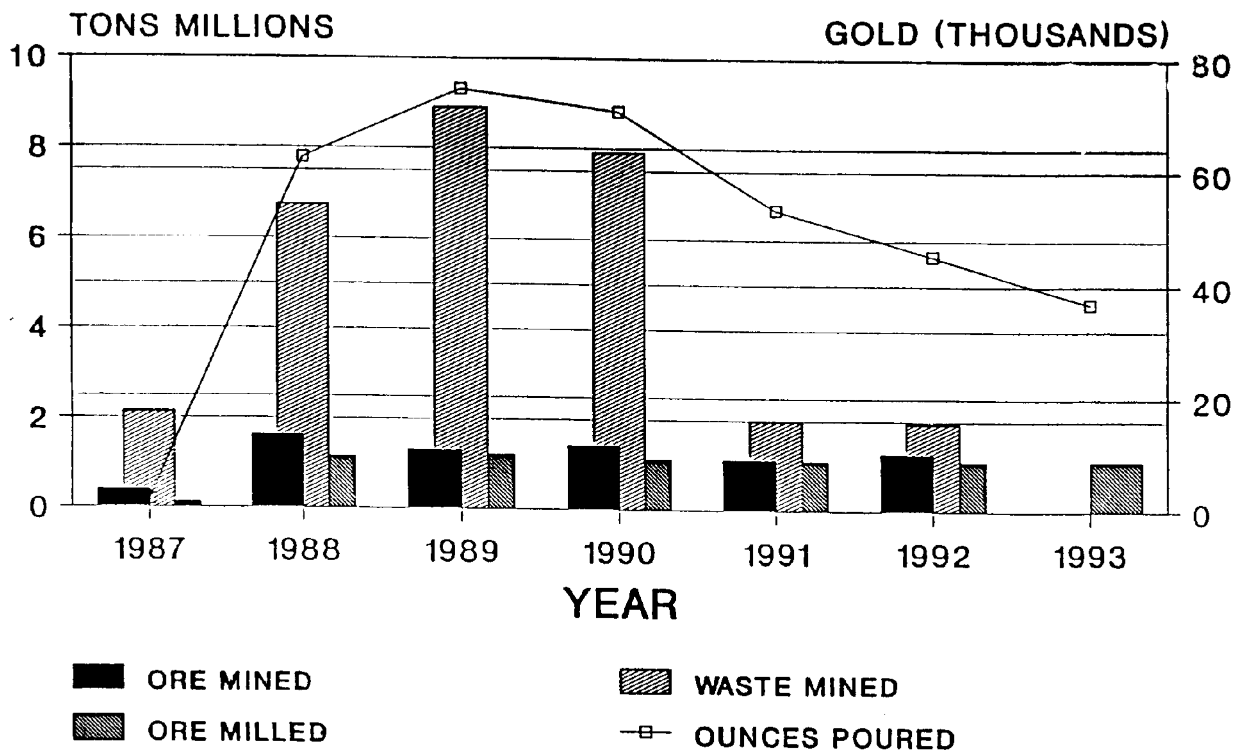

Figure 3-9. Life of Mine Statistics

(Source: Colosseum Inc., Undated)

emissions were reviewed by the Air Pollution Control District and no emission control device was deemed necessary. The furnace stack was given the identification number 08004 during the 1989 Air Toxics Emission Inventory. No further information was obtained on the operation of the furnace used to melt the gold and pour doré bars. According to Colosseum personnel, slag from the melting and pouring operation is first panned for coarse gold and then sent back to the SAG mill. The doré, averaging 70 percent gold and 30 percent silver, is sent to several different off-site refiners. In 1991, 61,553 troy ounces of gold were poured. Recovery of gold from ore averages 92 percent in the CIP/electrowinning circuit.

3.3 MATERIALS AND WASTE MANAGEMENT

The following section describes the specific wastes and materials generated and managed at the Colosseum Mine. Wastes managed on-site include waste rock and tailings, also called spent ore, from the CIP operation. In addition, other materials not typically considered wastes, such as mine water and low-grade ore, are managed on-site during the active life of the facility. Because these materials ultimately become wastes when intended for disposal (e.g., at closure of the facility), they are also addressed in this section. Figure 3-8 illustrates the life-of-mine statistics on waste rock, ore, and gold.

3.3.1 Waste Rock Piles

Colosseum has been removing waste rock from the two pits since the commencement of mining in 1987. The years 1988, 1989 and 1990 witnessed the greatest rate of waste rock generation at the site. Over these three years, approximately 23 million tons of waste rock were excavated and placed in piles onsite. In 1991, approximately two million tons of waste rock were removed from the two open pits. Colosseum has tested waste rock material using the acid-base accounting method for determining acid generating potential. According to Colosseum, results indicate that waste rock is not acid generating.

Waste rock excavated from the two open pits is disposed of in four different waste rock dumps. According to the Draft EIS, these waste rock piles were designed to cover 130 acres and accommodate up to 40 million tons of rock at the conclusion of mining. These four waste piles, designated as the East, West, North and Southwest piles, were formed by trucks dumping material into small ephemeral drainages adjacent to the two mine pits (see Figure 3-5). Most haulage distances are less than one-half mile. No liners underlie the waste piles and the dumps rest upon Precambrian crystalline rocks (see section 3.4.3). The mine dumps exist at their natural angle of repose (specific angle was not obtained), but are graded on occasion to provide access and to maintain the waste dump surface for receiving rock. Information on runoff controls at the waste rock piles was not obtained.

The current volume of rock contained in the waste piles and the height and size of the dumps was not obtained. The planned heights and elevations of each waste rock pile were included in the Draft EIS as follows: West dump would extend from an elevation of 5,250 feet above sea level to an elevation of 5,860 feet above sea level (total height of 610 feet), East dump would extend from an elevation of 5,435 feet above sea level to 5,920 feet above sea level (total height of 495 feet), Southwest and North dumps would range between 300 and 400 feet in height (Bureau of Land Management, et al., 1985a). No underdrain or sediment collection dams were proposed for these piles, according to the EIS. The EIS presented the following rationale for this decision (Bureau of Land Management, et al., 1985a):

- The slope of the waste rock surface will direct storm water runoff flow back toward the open pits;
- Due to low annual precipitation and high annual evaporation, percolation of storm water runoff is unlikely, and;
- In the event of storm water infiltration, any leachate created would contain the same compounds as the surrounding host rock; no sulfides were to be disposed of in the waste rock piles.

According to Colosseum personnel, at the end of mining, the waste rock piles will be graded to eliminate any "mesa-like" appearance. Original closure plans included the installation of two ground-water monitoring wells downgradient of the waste rock piles. However, since the site visit, Colosseum has indicated that they do not intend to install the monitoring wells. No additional information was provided.

3.3.2 Low-Grade Stockpile

At the time of EPA's visit, the low-grade stockpile contained 1.3 million tons of ore (a one year supply) grading 0.033 troy ounces of gold per ton (the lower grade cutoff between waste rock and low-grade ore was not determined, nor was the low-grade/high-grade cutoff). According to Colosseum personnel, this ore will be milled at the close of mining and no reclamation effort will be necessary. The stockpile area will be recontoured, topsoil added if available, and revegetated. No information was obtained about the construction of the pile. According to Colosseum, storm water runoff from the stockpile area is directed to the tailings impoundment. (It is not known if this stockpile was milled prior to closing the mill in May of 1993.)

3.3.3 Open Pits

According to Colosseum, mining of either pit is no longer economically feasible. However, given an increase in the price of gold, mining could resume. As a result, the two open pits have remained since mining ceased in July, 1992. As noted previously, the final depth of the South Pit is estimated to be 800 feet (no final depth was obtained for the North pit). Maps of the ore body indicate that abandoned underground workings were present in the South Pit prior to open pit mining (these workings are presumably the old Colosseum Mine) (Bureau of Land Management, 1985a). The EPA team did not observe adit or shaft openings in the walls or floor of the South Pit.

As noted in section 3.2.1, ground water discharges at a low rate into the pit bottom. The Reclamation Plan notes that a permanent pool of water (from ground water discharges or surface water runon) is not anticipated to collect in either pit. The perimeter of the pit is to be graded or bermed to intercept and divert runoff. According to the Reclamation Plan, any ground water which collects in the pit is expected to evaporate (Bond Gold Colosseum, Inc., Undated). No contingency plans were included in the Reclamation Plans in the event water formed an intermittent or permanent pool in the pit. No further reclamation of the pits is anticipated

Table 3-2. Chemical Analysis of Tailings Solids - Common Mineral Components (Unprocessed Ore Analysis)

Parameter	Concentration (percent)
Silicon Dioxide	75.90
Titanium Oxide	0.06
Aluminum Oxide	12.40
Ferric Oxide	0.61
Manganous Oxide	0.03
Magnesium Oxide	0.17
Calcium Oxide	0.16
Sodium Oxide	0.21
Potassium Oxide	8.51
Phosphorus Pentoxide	0.09
Total	98.14 *

KEY: * Loss on ignition accounts for an additional 1.16 percent.

Source: Bureau of Land Management, et al., 1985a.

with the exception of fencing and the posting of signs warning of potential danger to trespassers (Bond Gold Colosseum, Inc., Undated). According to Colosseum, the South Pit currently has standing water in the bottom, which was not anticipated during project planning. The Colosseum Mine is now conducting a ground water study, and will continue to work with the State Water Quality Control Board to develop a closure plan for the South Pit.

3.3.4 Cyanide Destruction Reactor

Colosseum uses the International Nickel Company (INCO) SO_2 cyanide destruction process to decompose free and complexed cyanide species in the tailings slurry. The INCO process injects SO_2 and air into a well-agitated vessel to oxidize cyanide in the tailings slurry and create inert cyanate complexes. At Colosseum, the solution is mixed with a 250 horsepower agitator as 2,000 standard cubic feet per minute of low pressure air is injected into the tank. Because acid is produced in the oxidation reactions, lime is added to the reaction tank to maintain a pH range of 8.5 to 9.0. Copper sulfate may be added to act as a catalyst for the oxidation reactions.

The tailings typically contain 50 percent solids by weight and 225 ppm WAD cyanide. Tank 11, a 13,025 cubic foot (100,000 gal) reactor tank, detoxifies tailings from the aeration tank in the CIP circuit in approximately 2.3 hours. A 2.3 hour residence time in a 100,000 gallon tank maintains a flow rate of 724 gpm, similar to the CIP flow rate. According to Colosseum, the final total cyanide concentration of the tailings slurry is less than 1.0 ppm. Detoxified slurry flows to the tailings sump and is tested every two hours for WAD cyanide. As required by Colosseum's waste discharge requirements, Colosseum collects at least three samples of tailings slurry per day to make one composite sample. The tailings slurry composite sample is separated into a solid fraction sample and a liquid fraction sample for analysis. These are shipped to an independent lab for total cyanide content analysis (see section 3.4.3). (Colosseum, Inc., 1992d)

3.3.5 Tailings Impoundment

Tailings from the INCO process are sent to a tailings sump at the mill which drains to the tailings impoundment via a pipeline (information on the tailings sump and pipeline was not obtained). Before designs for the tailings impoundment and cyanide destruction system were approved, Colosseum conducted a pilot program to determine the final composition of the tailings before cyanide destruction (details of the pilot

Table 3-4. Comparison of Original Estimate of Tailings Liquid Composition and Actual Annual Tailings Water Analyses

Parameter	Estimated* Composition	1988**	1989*** Min - Max	1990*** Min - Max	1991*** Min - Max
Cond, mmhos/cm	NA	6,540	7,110-9,210	3,320-7,440	5,720-7,670
Ph, su	NA	8.39	6.6-8.7	8.24-8.82	8.24-8.48
WAD CN, ppm	NA	0.00	0.0-0.8	0.02-0.17	0.07-0.14
Total CN, ppm	NA	0.01	0.21-0.45	0.02-0.26	0.03-0.18
Free and WAD Cyanide, ppm	106	NA	NA	NA	NA
TDS, ppm	NA	5,100	4,800-6,183	2,300-5,500	3,600-5,600
Sulfate, ppm	700	3,300	2,700-4,100	1,400-3,800	1,800-3,500
Sodium, ppm	2,200	670	490-880	260-760	370-750
Copper, ppm	52.8	0.36	0.0-1.6	0.22-2.8	0.09-1.7
Iron, ppm	39.4	0.11	0.00	0.00	0.00-<0.1
Zinc, ppm	31.9	0.0	0.11-2.5	0.08-0.25	0.02-0.12
Lead, ppm	NA	NA	NA	<0.002-0.003	<0.002-0.01

KEY: * - Data are from the Draft EIS, based on laboratory pilot tests of the ore.
** - Data presented for 1988 are from one quarter.
*** - Data presented for 1989, 1990 and 1991 are maximum and minimum values from quarterly sampling events.
NA - Not Available
ppm - parts per million
su - standard units
mmhos/cm- micromhos/centimeter

Source: Colosseum, Inc., 1992; Bureau of Land Management, 1985a.

Table 3-3. Minor and Trace Constituents of Colosseum Tailings Solids

Parameter	Concentration (mg/kg)
Antimony	<0.05
Arsenic	29.00
Barium	13.00
Ceryllium	0.44
Cadmium	4.30
Chromium (total)	6.70
Cobalt	5.50
Copper	158.00
Lead	158.00
Mercury	0.01 1
Molybdenum	1.50
Nickel	4.80
Selenium	0.15
Silver	0.27
Vanadium	2.80
Zinc	868.00
Thallium	<1.00

Source: Bureau of Land Management, et al., 1985a.

program were not available) (Bureau of Land Management, et al., 1985a). Tables 3-2 and 3-3 present the analytical results of tailing samples created in the pilot program. Table 3-4 presents a comparison of the estimated composition of tailings liquid (prior to cyanide destruction) as determined in the pilot tests and the actual composition of tailings liquid (after cyanide destruction) as sampled and analyzed throughout the life of the mine.

The tailings impoundment occupies the head of a canyon, approximately one-half mile south of the mill site (see Figures 3-4 and 3-5). The impoundment began receiving tailings in 1988. The native ground at the tailings impoundment location consists of shallow alluvial deposits covering Precambrian gneisses. As required by the reclamation plan for Colosseum, topsoil in the area to be occupied by the tailings impoundment was removed and stockpiled around the tailings impoundment (no further information was obtained on the topsoil stockpiles) (see section 3.4.1).

The tailings dam was constructed on top of a compacted foundation soil overlying Precambrian bedrock. A rock core was emplaced over the foundation soil and covered with compacted fill. The dam was designed to be raised by lifts (as production required) to a final design elevation of 5,375 feet above sea level. The impoundment created behind this dam would cover 150 acres and contain precipitation and runon from a 10,000 year, 24-hour storm event. The dam was also designed to withstand the Maximum Credible Earthquake (see section 3.1.4). Two small retention dams were also constructed along the perimeter of the tailings pond to prevent overflow into areas outside the tailings impoundment. An emergency spillway was constructed in 1991 on the northwest boundary of the tailings impoundment (Bureau of Land Management, 1985a; Colosseum, Inc., 1991). The emergency spillway was part of the original design and was constructed to handle the runoff from the PMF after the tailings area has been reclaimed. Waters overtopping the spillway would flow to the dry drainage below the tailings impoundment (the elevation of this spillway was not available). The approved reclamation plan required the construction of diversion channels for any ephemeral streams located in the tailings impoundment area if the tailings dam was not designed to store runoff from the Probable Maximum Flood (PMF) (it is unclear what recurrence interval was determined for the PMF storm). According to Colosseum, since the tailings dam was designed to store the runoff from the PMF, no diversion channels are required.

Green's Well (a livestock watering well) and mine shafts leading to abandoned underground tungsten workings in Precambrian gneisses, were in the middle of the proposed tailings impoundment location. As a condition of Colosseum's waste discharge requirements, these shafts and tunnels were to be backfilled and sealed to prevent discharges of tailings water into the ground water (see section 3.4.3). Information on the methods used to backfill and seal these openings was not obtained.

As of December 1991, 4,805,250 tons of tails had been placed into the impoundment. Tailings are piped from the mill to a distribution pipeline that encircles the impoundment and discharged through subaerial deposition. Subaerial deposition of tailings produces a maximum density tailings, while providing reclaim water by avoiding excess interstitial water in the tails. According to Colosseum personnel, the dam was raised to a crest elevation of 5,341 feet above sea level in 1991 and it is anticipated that no further raising of the dam will be necessary before reclamation begins. During the site visit, the dam appeared to be about 100 feet high. According to Colosseum personnel, the current impoundment will contain the precipitation and runon from the 1,000 year, 24-hour storm event and it is now approved to store tailings to elevation 5,336 feet above sea level, with a final freeboard of five feet.

According to Colosseum personnel, the 17 inches per year in evaporation results in a net deficit of available water for the mine. Tailings water is reclaimed off the pond and pumped to the mine's process water tank. Ten piezometers placed along the downstream face of the dam record water levels in the core to ensure the correct functioning of the dam. (Colosseum, Inc., 1992b).

The tailings impoundment is unlined and an underdrain system collects tailings dam seepage and conveys the liquid to two ponds located downstream of the dam (size and capacity of the ponds was not obtained). Seepage enters the ponds at an average rate between 50 and 90 gallons per minute (variability is seasonal) and is pumped back to the tailings impoundment. According to Colosseum personnel, seepage in the first year of operation was at a rate greater than the pumping system could maintain. The underdrain system is valved and the flow was restricted to the pump capacity for the first year of operation. The tailings subsequently sealed the impoundment as designed and the flow has slowed to current levels. According to Colosseum, there was no discharge. The two seepage collection ponds are double-lined with 40-mil high density polyethylene (HDPE) liners. A leak detection system, consisting of geotextile fabric, six inches of sand and a network of perforated pipe draining to an inspection sump, was installed between the liners of each pond. The leak detection system is required to be checked visually each month, and, if liquid is present, a sample must be collected and analyzed for the parameters listed in the Monitoring and Reporting Program No. 87-20 for the Colosseum Gold Mine (see section 3.4.3) (California Regional Water Quality Control Board, Lahontan Region, 1987a; 1987b).

Several monitoring wells have been installed in the tailings impoundment area. Figure 3-4 illustrates the location of these monitoring wells. Five of these wells (MW4, MW5, West, South and Gorge Wells) are sampled on a quarterly frequency. Wells MW1, MW2 and MW3 were installed downgradient of the tailings impoundment and completed in Cambrian sedimentary units, alluvium and Precambrian gneiss, respectively (Sergent, Hauskins and Beckwith, Undated). According to Colosseum personnel, these latter three wells were dry upon completion and have never contained water. Monitoring results indicate that the tailings water may be migrating toward the West well. However, according to Colosseum, current studies may indicate that sulfate levels may not be the result of the tailings water. Colosseum, in cooperation with the State Water Quality Control Board, is conducting further studies to research this issue. Further information, including monitoring results, are presented in section 3.4.3.

Reclamation on the tailings impoundment will begin after all stockpiled ore has been leached in the CIP circuit, probably sometime in 1994. The approved reclamation plan for the tailings impoundment requires the following elements:

- Cover downstream slope of tailings dam with mine waste rock to minimize erosion. Reestablish vegetation through natural processes;
- Cover top of tailings impoundment with mine waste rock or salvaged topsoil (to the extent available). Grade top of tailings to direct surface runoff and prevent long-term ponding of precipitation. Reseed with indigenous plants or plants established successfully in a similar environment. Construct berms on the impoundment to discourage entrance. During the site visit, EPA viewed an experimental garden of transplanted indigenous plants. Certain species appeared to have made a successful transplant.
- Maintain seepage ponds for several years; and
- Retain diversion channels, if constructed around the tailings impoundment.

3.3.6 Other Wastes and Materials Reused/Recycled

Waste oil generated at the mine is collected by a contractor every ninety days for off-site recycling. The name of the contractor was not obtained. No information was obtained on the quantity of waste oil generated. Other oil/lubricant-contaminated wastes generated at the mine include: soil (from minor spills), oil filters and rags contaminated with used motor oil, used crater grease (from axle lubrication) and empty 55-, 15- and 5-gallon drums/pails with residual crater grease/motor oil (from lubricating operations). Specific quantities of these wastes were not obtained. These wastes are collected by Disposal Control Services and shipped off-site for disposal.

In 1991, Colosseum generated a wide variety of wastes at the laboratory and mill. Assorted wastes generated in the laboratory and mill, including borax, flocculent, fluorospar, paint and rubber cement, were collected and hauled off-site for disposal by Disposal Control Services (volumes of these wastes were not obtained). Colosseum annually generates approximately 1.5 barrels of lead-contaminated cupels from the fire assay process. Spent solvents are also generated (specific amounts were not obtained). All of these wastes are picked up and transported off-site for disposal by Disposal Control Services.

Spent electrowinning solutions are brought back to strength and reused. Spent carbon is regenerated and reused. Spent carbon stripping solutions are used as cyanide addition to tank 2. The CIP tanks are periodically drained and checked. The tanks are hosed clean and all residue is milled for contained gold. The ore slurry "trash" is treated as mill tailings. No information on the quantities of these wastes generated was obtained.

Paper and trash are hauled by Desert Disposal Services to a landfill in Barstow. Sanitary sewage is discharged to a septic tank at the mine (location of the septic tank was not obtained).

3.4 REGULATORY REQUIREMENTS AND COMPLIANCE

Colosseum is subject to both Federal and State regulatory requirements and their attendant permits. Two statutes, the National Environmental Policy Act and the California Environmental Quality Act, require that the proposed action (the mine operating plan) and alternative actions (i.e. alternatives to the plan) be evaluated for their environmental consequences. Because portions of the mine are located on lands administered by BLM in San Bernardino County, the BLM was designated the lead agency for NEPA compliance. The County was designated as the lead agency for CEQA (the County is also the permitting agency for reclamation and air pollution control as designated by the State). Through a Memorandum of Understanding among these two agencies and Colosseum, an Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was prepared and approved for the Colosseum Mine.

3.4.1 Bureau of Land Management

As noted previously, the Colosseum mine site lies almost exclusively on Federal lands administered by the Bureau of Land Management. Mining on these lands is subject to regulations set forth in 43 CFR Part 3800, "Mining Under the General Mining Laws." These regulations were promulgated by the Bureau of Land Management under authority of the Federal Land Policy and Management Act (FLPMA). The regulations provide BLM with the authority to approve a Plan of Mining Operation on Federal Lands prior to commencement of operations, to require bonding, and to inspect mining operations to ensure the operator is complying with these regulations (45 FR 78902).

Pursuant to these regulations, the Colosseum mine submitted a Plan of Operations to BLM and the County of San Bernardino for approval (see section 3.4.2). Included as part of the mine operating plan is a reclamation plan that describes the planned activities before, during, and after the operation which will ensure the stabilization and reclamation of areas disturbed by mining.

Upon approval of the mine operating plan, Colosseum furnished to BLM (jointly with the State of California Department of Conservation, Division of Mines and Geology) a stand-by letter of credit (from the Royal Bank of Canada) to cover the cost of reasonable stabilization and reclamation of areas disturbed by mining at the Colosseum site. The letter of credit is in the amount of $762,181 and was to expire in February 1993 (Royal Bank of Canada, 1992). The bonding amount is reviewed yearly and adjusted as deemed necessary by the BLM and the State.

A list of mitigative measures was developed for the EIR/EIS. These were incorporated into the Operating Plan. These measures include:

- Elevate fresh water pipeline to allow unrestricted movement of the desert tortoise (an endangered species which lives in Ivanpah Valley)
- Apply dust suppressant on access road (Colosseum uses water soluble lignin sulfonate) twice a year
- Limit traffic on the mine access road (Colosseum provides transportation for employees in a 15-passenger van from Las Vegas to the mine)
- Purchase and set aside desert land suitable as tortoise habitat to mitigate loss of 10 acres of habitat caused by access road
- Install wildlife troughs
- Treat fresh rock surfaces (road cuts) with "Eonite" (which mimics desert pavement through a chemical reaction with rock)
- Fence around tailings impoundment
- Paint buildings to blend in with the environment.

The BLM (Needles Resource Area) inspects the Colosseum mine monthly to ensure compliance with the approved mine operating plan.

3.4.2 California Department of Conservation, Division of Mines and Geology

The California Department of Conservation, Division of Mines and Geology, provides technical support for the lead agencies (i.e., counties or cities) with responsibility for enforcing the requirements of the State's Surface Mining and Reclamation Act (SMARA). For Colosseum, the lead agency is the County of San Bernardino. The State legislature passed SMARA in 1975 to ensure that minded lands in California are reclaimed. SMARA is triggered when a mine disturbs over one acre of land or produces over 1,000 cubic yards of waste/ore per day. Regulations for the implementation of SMARA were promulgated under California Code of Regulations, Title 14, Chapter 8, Subchapter 1, Article 1. Surface Mining and Reclamation Practice. The most significant reclamation requirements outlined in this regulation is the submittal of a reclamation plan to the lead agency by the mining facility. Upon approval of the plan, the lead agency issues a permit to the facility to operate. A reclamation plan for the Colosseum Mine was submitted to the County of San Bernardino for approval in conjunction with the development and approval of the EIR/EIS.

Although the County of San Bernardino was identified in the EIR/EIS as the lead agency for the State, the Division of Mines and Geology is the beneficiary (jointly with BLM) of the stand-by letter of credit provided by Colosseum to insure the performance of reclamation activities (Royal Bank of Canada, 1992). The County inspects the mine yearly for compliance with the approved reclamation plan.

3.4.3 California Regional Water Quality Control Board, Lahontan Region

The California Regional Water Quality Control Board also is responsible for regulating discharges of mine wastes to land under the California Code of Regulations Title 23, Chapter 3, Subchapter 15, Article 7, Discharges of Waste to Land. These regulations require that facilities discharging waste to land submit a report of this discharge to the Regional Board. Upon receipt of the report, the Board reviews the information, classifies the wastes and issues waste discharge requirements to the facility in the form of a Board Order.

The Colosseum mine, as a gold cyanide mill, is subject to the zero discharge requirements of 40 CFR 440(j): that is, it may not discharge mill effluent (including tailings) to waters of the United States. Thus, no NPDES permit has been issued to the facility by the Lahontan Regional Water Quality Control Board.

Colosseum is not authorized to discharge to surface waters but two wastes generated at the Colosseum mine are subject to the requirements of State regulations: tailings and waste rock. The Lahontan Region Board classified the tailings produced at Colosseum as Group B wastes. These wastes are defined as wastes that consist of or contain hazardous wastes that qualify for a variance under Section 66310 of Title 22 of this code, or wastes that consist of or contain nonhazardous soluble pollutants in concentrations that exceed water quality objectives for, or could cause degradation of, waters of the state. The Board exempted these wastes from the liner requirement, based on a geotechnical report prepared for the project that indicates that only limited amounts of groundwater underlie the project site and that hydraulic interconnection between the project site and major aquifers (Ivanpah and Shadow Valley) appears to be limited. (This report was not obtained). However, additional monitoring requirements were included in the permit to provide early detection of wastewater migration.

The waste rock was classified as a Group C waste by the Lahontan Regional Board. These wastes are defined as wastes which would be in compliance with the applicable water quality control plan, including water quality objectives, other than turbidity. No liner is required for disposal areas receiving Group C wastes.

Colosseum operates under the California Regional Water Quality Control Board, Lahontan Region Board Order No. 6-87-20, Revised Waste Discharge Requirements for Colosseum Gold Mine, San Bernardino County, California and the accompanying Monitoring and Reporting Program No. 87-20 for the Colosseum Gold Mine, San Bernardino County, California. The Order prohibits the discharge of any detoxified wastewater, waste rock or detoxified tailings slurry except into an authorized disposal site. Further, the Order limits the concentration of cyanide (total and WAD) in tailings discharged to the tailings impoundment. Total cyanide may not exceed 1.0 mg/l and WAD cyanide may not exceed 0.5 mg/l in the liquid tailings fraction, as averaged over a period of 30 consecutive sampling days. For the solid fraction, total cyanide may not exceed 18.0 mg/kg and extractable total cyanide may not exceed 0.5 mg/l. The Order also contains a (standard) narrative requirement that discharges to the waters of the State shall not contain substances in concentrations that are toxic to, or produce detrimental physiological responses in humans, plants, animals, or aquatic life.

In addition to the effluent limitations specified in the waste discharge requirements, the Order contains requirements and prohibitions for specific components at the site as well as general requirements and prohibitions. These include:

3.4.3.1 Cyanide Detoxification Facility (INCO)

- Effectively seal all cyanide leaching facilities (including leaching tanks and collection ponds), to prevent the exfiltration of any liquids used in the extraction or detoxification processes

3.4.3.2 Tailings Impoundment

- Provide seepage detection systems on collection ponds
- Construct the collection ponds and tailings impoundment in compliance with the requirements for Group "B" mining wastes, except as allowed for the tailings impoundment (i.e., the waiving of liner requirements)
- Discontinue use of seepage collection pond and tailings impoundment upon presence of liquid (containing in excess of 0.2 mg/l free cyanide) in the leakage detection system

- Cease discharge of tailings to the impoundment in the event free cyanide (exceeding 0.2 mg/l) or any other monitored parameter exceeding 20 percent of background concentrations are detected in ground water or surface water outside the boundaries of the tailings impoundment

- Backfill and seal as necessary, all adits and/or tunnels located within the tailings impoundment site, to prevent discharges of tailings water directly into the groundwater

- Discharge, bypass, or divert no cyanide leaching solution, neutralization water, or tailings slurry from the collection, transport, treatment or disposal facilities to adjacent land areas or surface waters

- Discharge no surface flow of any leaching solution, neutralization water, or tailings slurry from the authorized disposal sites to adjacent land areas or surface waters

- Construct the tailings impoundment and waste rock disposal areas to protect against overflow, washout, inundation, structural damage or a significant reduction in efficiency resulting from precipitation and peak surface runoff flows from the 100-year, 24-hour storm event

- Maintain a vertical distance between the liquid surface elevation and the lowest point of a pond dike or invert of an overflow structure of at least 2.0 feet

3.4.3.3 Waste Rock Piles

- Construct the waste rock piles in compliance with the for Group "C" mining wastes.

3.4.3.4 General Requirements

- Cause no pollution or threatened pollution from the discharge (to land)

- Cause no nuisance in the treatment or discharge of waste

- Comply with the engineering plans, specifications, and technical reports submitted with the completed report of waste discharge

- Dispose of all cyanide-contaminated waste materials, other than tailings, at a Class I disposal site or neutralize and discharge at a Class III disposal site

- Store all hazardous material containers in a secured storage facility that is not susceptible to the elements, vandalism or potential public contact

- Post signs warning the public of the presence of cyanide.

Several other provisions were included in the Order, including the submittal of a final closure plan 180 days prior to beginning any partial or final closure activities or at least 120 days prior to discontinuing the use of the site for waste treatment, storage or disposal. One of the more important provisions of the Board Order is the required compliance with Monitoring and Reporting Program No. 87-20.

The monitoring and reporting program establishes the requirements for water quality monitoring and reporting with respect to the discharge of waste to land at Colosseum. The program requires the recording of information, the sampling and analysis of liquids, ground water, surface water and the quarterly reporting of the information and results of the analyses. Pursuant to the program, Colosseum records a number of production statistics, including the total quantity of ore processed, the total quantity of detoxified tailings discharged to the tailings impoundment, and the total quantity of waste rock placed at each of the four dump sites (a report containing all of this data was not obtained).

As discussed in section 3.3.1, Colosseum is required to collect two composite samples daily (composites of three individual samples) of the solid and liquid fractions of the tailings slurry. Both the solid and liquid fractions are to be analyzed for total dissolved solids (reported in mg/l) and total cyanide (reported in mg/l). The liquid fraction has to be analyzed for WAD cyanide (reported in mg/l); the solid fraction has to be analyzed for extractable cyanide (reported in mg/l).

The tailings impoundment return water must be sampled weekly (one grab and one 24-hour composite) and analyzed for TDS, total cyanide and WAD cyanide. Results of these analyses were not obtained.Ground water monitoring requirements also are included in the monitoring and reporting program. Table 3-5

Table 3-5. Results of Required Ground Water at the Colosseum Mine

Parameter	Minimum and Maximum Concentrations in Ground Water Monitoring Wells at Colosseum				
	West Well*	MW5**	MW4***	Gorge Well****	South Well*****
Conductivity, mmhos/cm	920 -1,493	1,419 - 1,697	1,022 - 1,300	1,117 - 1,365	842 -939
pH	6.6 - 7.48	7.15 - 7.86	7.34 -7.79	7.11 - 8.04	6.92 - 7.47
WAD Cyanide, ppm	<0.005 - <0.125	<0.005 - <0.125	<0.005 - <0.125	<0.005 - <0.125	<0.005 - <0.125
Total Cyanide, ppm	<0.005 - <0.25	<0.005 - <0.25	<0.005 - <0.25	<0.005 - <0.25	<0.005 - <0.02
TDS, ppm	490 - 850	760 -1,000	590 - 662	500 - 690	370 - 470
Sulfate, ppm	50 -290	94 - 250	57 - 140	<1.0 - 90	18 - 69
Sodium, ppm	36 - 63	51 - 71	70 -95	42 - 58	29 - 43
Copper, ppm	<0.01 - 0.03	<0.0015 - 0.03	<0.001 -0.04	<0.002 - <0.02	<0.002 - <0.02
Iron, ppm	<0.02 - 0.15	<0.02 - 0.1	<0.002 - .17	<0.02 - .67	<0.02 - 0.13
Zinc, ppm	<0.02 -8.1	<0.01 - 0.07	<0.005 - 0.04	.82 - 8.3	<0.03 - 5.3
Lead, ppm	<0.01 - <0.2	<0.002 - 0.002	<0.001 - 0.003	<0.002 - .003	<0.001 - <0.2

KEY: *Data represent monthly sampling from Sept 1987 to Sept. 1988, quarterly monitoring from Jan. 1989 to Dec. 1990, and monthly sampling from Jan. 1991 to Dec. 1991.

**Date represents monthly sampling from Jan. 1988 to Oct. 1988 and quarterly sampling from Oct. 1988 to Dec. 1991.

***Data represents monthly sampling from Nov. 1987 to Oct. 1988 and quarterly sampling from Jan. 1989 to Dec. 1991.

****Data represents monthly sampling from Nov. 1987 to Oct. 1988 and quarterly sampling from Jan. 1989 to Dec. 1991.

*****Data represents monthly sampling from Jan. 1988 to Oct. 1988 and quarterly sampling from Jan. 1989 to Dec. 1991.

Source: Colosseum, Inc., 1992a.

presents analytical results for the six wells containing water (beginning in 1987 for West, MW4 and Gorge wells and 1988 for MW5 and South wells). All but the Gorge well (also known as the East well) are local to the tailings impoundment. MW1, MW2 and MW3 are dry and have never been sampled. Established limits for these wells were not available, but, a general provision of the waste discharge requirements dictates that free cyanide may not exceed 0.2 mg/l and other monitored parameters may not exceed 20 percent of background concentrations in ground water. It is unclear what background concentrations were established for the monitored parameters.

Colosseum's Annual Water Quality Monitoring Report for 1991 states that levels of sodium, sulfate, TDS and conductivity are in excess of the permitted levels for the West well. Colosseum initially thought that these high levels probably result from the migration of tailings water pooled along the western edge of the impoundment near the West well (see Table 3-5). However, the Colosseum Mine now believes that baseline sulfate levels were artificially lowered by pumping away surface waters during construction. The Colosseum Mine has collected soil samples up gradient of the West well that indicate that surface runoff to the well could be a natural cause for the current sulfate levels. The results and the interpretations are currently being discussed with State Water Quality Control Board staff.

The monitoring and reporting program also requires the quarterly sampling of eight springs, labeled as S-11 to S-18 (the location of these springs was not obtained), for the following parameters: conductivity, pH, temperature, total cyanide, WAD cyanide, TDS, sodium, sulfate, zinc, copper and iron. No analytical data on the sampling of these springs was obtained.

As noted in section 3.3.2, the leakage detection sumps must be visually inspected each month for the presence of liquid. If liquid is detected, it must be analyzed for: total cyanide, WAD cyanide, TDS, sodium and sulfate.

The Regional Water Quality Board also requires Colosseum to provide financial assurances that monies are available to ensure closure upon abandonment of the facility. The bond was in the form of a stand-by letter of credit from the Royal Bank of Canada in the amount of $735,000 (Royal Bank of Canada, 1992a). This bond is separate from the reclamation bond described in section 3.4.1.

3.4.4 Air Pollution Control District, San Bernardino County

Colosseum holds fourteen permits issued by the Air Pollution Control District, San Bernardino County, California, for the operation of various components of the Colosseum Mine (San Bernardino County Air Pollution Control District, 1991a). These are shown in Table 3-6

Table 3-6. Air Pollution Control Permits

Permit Number	Unit Covered	Special Conditions of the Permit
B001822	Ore Crushing Unit	• Unit must only operate concurrently with the wet scrubber permit #001830 • Ducting to the wet scrubber must be maintained as air tight. • Dust control water sprays must be functioning at the ore bin when ore is dumped by haulage trucks. • Mining is limited to 31,000 tons of rock per 24-hour day. • Operator must maintain a log of mining rates.
B001823	Leach and Carbon Adsorption	• Water sprays must be working during the addition of ore to the crushed ore stockpile. • Water sprays shall be used in severe weather conditions (strong winds) when ore in not being added to the stockpile.
B001824	Leach and Carbon Adsorption	• Equipment must be maintained and operated consistent with manufacturer's recommendations and/or sound engineering practices.
B001825	Tailings Thickener and Treatment Unit	• Equipment must be maintained and operated consistent with manufacturer's recommendations and/or sound engineering practices.
B001826	Carbon Stripping and Regeneration Unit	• Equipment must be maintained and operated consistent with manufacturer's recommendations and/or sound engineering practices.
B001827	Cyanide Destruction Unit	• Operate concurrently with and vented to the functioning lime bin baghouse (permit C001832) • Equipment must be maintained and operated consistent with manufacturer's recommendations and/or sound engineering practices.
B001828	Plant Air Compressors	• Equipment must be maintained and operated consistent wit manufacturer's recommendations and/or sound engineering practices.
B001830	Scrubber - Venturi	• Operate concurrently with the crushing unit and appurtenai equipment. • Maintain entire system consistent with manufacturer's recommendations and good engineering practices. • Maintain log on-site • Conduct emission tests (within 90 days of receipt of this permit) on outlet of scrubber to determine compliance.
C001831	Water Sprays (Fine Ore)	• Maintain in good working order consistent with sound engineering practices to ensure emissions compliance. • Operate when fine ore is added to stockpile. • Operate during severe weather (strong winds).

Table 3-6. Air Pollution Control Permits (continued)

Permit Number	Unit Covered	Special Conditions of the Permit
B001832	Lime Bin Dust Collector	• Maintain a minimum inventory of bags at 50 percent of the required bags. • Maintain an on-site log of all inspections, repairs, and maintenance performed.
B001833	Lime Bin Dust Collector	• Maintain a minimum inventory of bags at 50 percent of the required bags. • Maintain an on-site log of all inspections, repairs, and maintenance performed.
B002295	Portable Lime Slaking Unit	• Operate in accordance with recommendations of the manufacturer and sound engineering principles. • Ensure sufficient liquid in Porta Batch Mixing Tank prior to connecting of pneumatic devices.
B002588	Cone Crusher	• Ensure that the materials processed contain sufficient natu and natural moisture for compliance. • Provide piping to effect any necessary addition required to avert water freezing. • Construct to be air tight as practicable to preclude fugitive emissions and to allow retrofit of control equipment in the future.
T003024	Gasoline Dispensing Facility (Non-Retail)	• Post toll free telephone number.

Source: San Bernardino County Air Pollution Control District, 1991a through 1991n.

, along with a listing of special conditions imposed upon each unit. General conditions the permits include:

- Comply with all applicable rules and regulations of the San Bernardino County Air Pollution Control District, and

- Ensure that construction, maintenance and operation of the stationary source is in compliance with all applicable provisions of Federal, State and District regulations.

3.4.5 Other Permits

The Colosseum Mine also holds permits from the California State Division of Safety of Dams and the Environmental Health Services Department, San Bernardino County, California.

Colosseum Mine was issued a permit (number 2800) by the Division of Safety of Dams for the operation of the mine tailings dam. An annual operational report is submitted to the Division containing a number of statistics (e.g., the current dam crest level, the total tailings deposited in the impoundment throughout the year, etc) (Colosseum, Inc., 1992b). The requirements of this permit were not obtained.

The mine is a small quantity generator of hazardous waste and is identified by the mine's EPA Hazardous Waste Number CAD982459968. The mine has two hazardous waste permits issued by the Environmental Health Services Department, San Bernardino County, California. Permit No. 8709080011 allows Colosseum to handle hazardous materials. Permit No. 8709080010 allows Colosseum to generate hazardous waste. The requirements of these permits were not determined (County of San Bernardino, Environmental Health Services, Undated).

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San Bernardino County Air Pollution Control District. 1991g. Permit No. B001828 to Operate Plant Air Compressors. August 8, 1991.

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APPENDIX 3-A

COMMENTS SUBMITTED BY COLOSSEUM ON DRAFT SITE VISIT REPORT

[Comments not reproduced for this electronic version. Copies may be obtained from U.S. EPA, Office of Solid Wastes, Special Waste Branch.]

APPENDIX 3-B

EPA RESPONSE TO COMMENTS SUBMITTED BY COLOSSEUM INC.

EPA Response to Comments Submitted by
Colosseum, Inc. on Draft Site Visit Report

EPA has revised the report to address all of the comments made by Colosseum, Inc., submitted following their review of the Draft Site Visit Report dated September 1992. In some cases, EPA made changes to wording suggested by Colosseum, either for brevity, in order to attribute changes to Colosseum, or to enhance clarity.

MINE SITE VISIT:

NERCO MINERALS
CRIPPLE CREEK OPERATIONS

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street SW
Washington, DC 20460

4.0 SITE VISIT REPORT: NERCO MINERALS CRIPPLE CREEK

4.1 INTRODUCTION

4.1.1 Background

The Environmental Protection Agency (EPA) is assisting states to improve their mining programs. As part of this ongoing effort, EPA is gathering data related to waste generation and management practices by conducting site visits to mine sites. As one of several site visits, EPA visited the Ironclad/Globe Hill facility near Cripple Creek, Colorado, on April 14, 1992.

Sites to be visited were selected to represent both an array of mining industry sectors and different regional geographies. All sites visits have been conducted pursuant to RCRA Sections 3001 and 3007 information collection authorities. When sites are on Federal land, EPA has invited representatives of the land management agencies (Forest Service/Bureau of Land Management). State agency representatives and EPA regional personnel have also been invited to participate in each site visit.

For each site, EPA has collected information using a three-step approach: (1) contacting the facility by telephone to get initial information, (2) contacting State regulatory agencies by telephone to get further information, and (3) conducting the actual site visit. Information collected prior to the site visit is then reviewed and confirmed during the site visit.

In preparing this report, EPA collected information from a variety of sources, including Nerco Minerals Company, the Colorado Mined Land Reclamation Division, and the Colorado Department of Health. The following individuals participated in the site visit:

<u>Nerco Minerals Company</u>

Jim Muntzert, Mine General Manager, Pikes Peak Mining Company	(719) 689-2977
John Woodward, Manager, Environmental Compliance	(503) 796-6600

<u>Colorado Mined Land Reclamation Division</u>

Bruce Humphries, Minerals Program Supervisor	(303) 866-3567
Carl B. Mount, Senior Reclamation Specialist	(303) 866-3567

<u>U.S. Environmental Protection Agency</u>

Van Housman, Chemical Engineer	(703) 308-8419
Rob Walline, Mining National Expert	(303) 293-7093

Science Applications International Corporation

Jack Mozingo, Environmental Scientist (703) 734-2513
Laurie Lamb, Geologist (303) 292-2074

Participants in the site visit were provided an opportunity to comment on a draft of this report. Nerco Minerals Company submitted comments on the draft, which are presented in Appendix 4-C. EPA's responses to Nerco Minerals Company's comments are summarized in Appendix 4-D.

4.1.2 General Facility Description

The Ironclad/Globe Hill facility and Nerco's other Cripple Creek operations are located in Teller County, Colorado, near the historic mining towns of Cripple Creek and Victor (see Figure 4-1

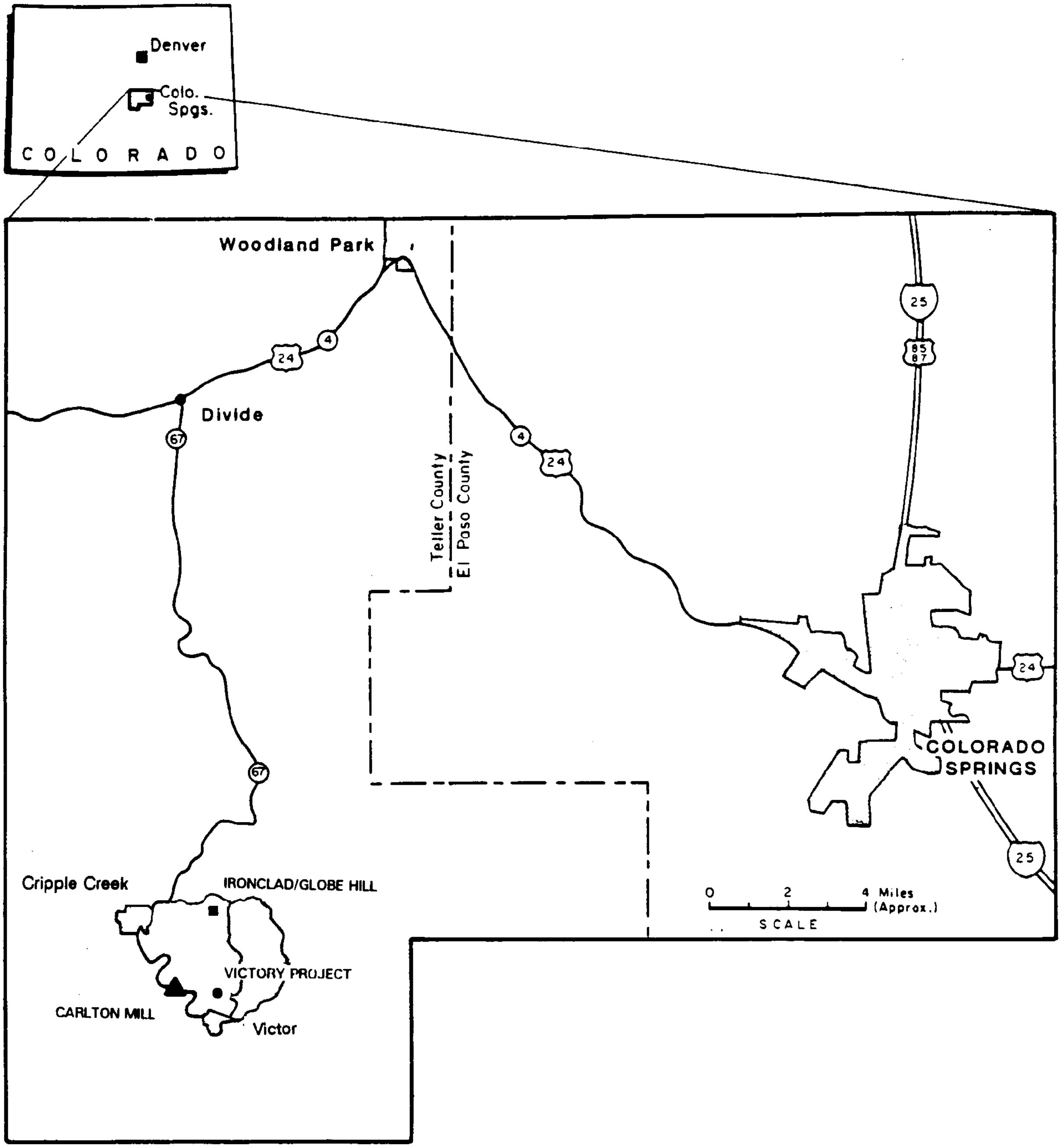


Figure 4-1. Cripple Creek and Victor, Colorado, and Major Nerco Operations

(Source: Map used in numerous permit applications, modified by EPA)

). Mining has occurred in the area since the mining district was organized during the gold rush of the early 1890s. The mining district is characterized by abandoned headframes, waste rock dumps, and hundreds of openings to underground mines. Other than mining, predominant land uses include grazing and ranching. The colorful mining past, reflected in the remnants of historic operations, also makes tourism a mainstay of the local economies. In Cripple Creek, recently authorized gambling has begun to dominate the economy.

Nerco Minerals owns a number of major operations in the Cripple Creek area, all within one to two miles of the towns of Cripple Creek and Victor. Nerco's major current activities occur on two main permits issued by the Mined Land Reclamation Division: the Globe Hill and Ironclad/Victor permits.

The Globe Hill project (MLRD permit number 77-367) was initiated by Gold Resources Joint Venture in 1977 as an open pit mine and the Globe Hill heap leach pad. Newport Minerals became the permittee in 1979 (Newport Minerals, Inc. 3/29/79) and operated two additional heap leach pads: the Forest Queen/2A pad, which was constructed on the surface of waste rock from the pit; and the '76 or Bull Hill project, which was used to leach material taken from old waste rock dumps and is located about one mile southeast of the Ironclad/Globe Hill site. In 1986, Dayspring Mining Corporation succeeded Newport as the permittee for the entire Globe Hill project and other projects covered by Permit 77-367 (MLRD 9/25/86). In 1990, Nerco (actually, Nerco subsidiary Pikes Peak Mining Company) succeeded Dayspring as operator (MLRD 2/6/91). None of the three permitted heap leach pads has been actively leached for several years.

The Ironclad/Victor operation (permit 81-134) is immediately adjacent to the Globe Hill permit area. Permitted by Silver State Mining Company in 1981, this operation originally leached ore from the Ironclad pit in concrete vats inside the Victor Mill building. Nerco purchased Silver State and assumed the permit in 1984 and undertook a major expansion. In late 1985, the facility entered an extended period of inactivity. Nerco then attempted to sell the Victor property, along with three mines in Nevada, in 1988 (Nerco 9/88). This "small mines package" was withdrawn from the market in 1989 (Nerco 9/89) as Nerco consolidated control over much of the Cripple Creek mining district. In 1990, Nerco developed plans to re-activate the facility, again as a vat leaching operation. Shortly thereafter, Nerco (through Pikes Peak Mining Company) assumed the adjacent Globe Hill permit and developed plans for a large 1,500,000 square foot heap leach pad covering portions of both permit areas. This pad, the "Ironclad Pad," is being constructed in three phases during 1991 and 1992, and portions of the developing heap are being actively leached as construction continues on other portions. Ore for this heap is mined from the Ironclad and Globe Hill open pits. Ultimately, the heap will contain a total of about 4,400,000 tons of ore.

Besides the Ironclad/Globe Hill operation, Nerco owns and/or controls a number of other operations and facilities in the Cripple Creek area: the Carlton Mill (Pads 1 and 2), the Victory Project (the Portland pit and Pads 3 and 4), the Gold Star open pit, many mine dumps, and large undeveloped areas. Permitted areas are shown in Figure 4-2 and are listed in Table 4-7. Pads 1, 3, and 4 were no longer being actively leached, although reclamation had not begun at the time of the site visit; similarly, the Gold Star and Portland pits were no longer being mined, and reclamation of the Portland pit had begun. In addition, Nerco is the NPDES permittee for discharges from the Carlton tunnel, a tunnel that drains much of the mining district. Nerco also has an active exploration program and is preparing to develop a major open pit mine and heap leach operation in the area: the Cresson Mine. This operation will be located northwest of the town of Victor. At the time of the site visit, Nerco planned to submit the permit application for this mine later in 1992. During the site visit, Nerco and MLRD indicated that there was some local opposition to the development.

As in many historic mining districts, land ownership patterns are extremely complex. Nearly all of the district consists of patented lode claims that over the years entered private ownership through the general mining laws. Through leases, purchases, and other agreements, Nerco now controls about 95 percent of the district, a total of about 14,000 acres. The Bureau of Land Management retains something less than one percent of the area in parcels ranging up to 0.25 acres in size.

Nerco Minerals Company is owned by Nerco, Incorporated, which also has extensive coal and oil holdings; the parent company of Nerco, Incorporated, is Pacificorp. Permits issued by the Colorado Mined Land Reclamation Division for the various Cripple Creek operations are issued to one of several companies: Nerco Minerals (Victor Mine permit 81-134), Pikes Peak Mining Company (Globe Hill permit 77-367), and Cripple Creek and Victor Gold Mining Company (Victory permit 86-024, Carlton Mill permit 80-244, and the Carlton Tunnel NPDES permit). Much of Nerco's Cripple Creek property is held by Cripple Creek and Victor Gold Mining Company (CC&V), a joint venture between Nerco subsidiary Pikes Peak Mining Company (67 percent) and the Golden Cycle Gold Corporation (33 percent). Mining operations are managed by Pikes Peak Mining Company, which was known as Texasgulf Minerals and Metals prior to its 1989 purchase from ELF Aquitane. For ease of reference, this report simply refers to "Nerco" when discussing the owner, operator, and/or permittee of any of the Cripple Creek operations.

4.1.3 Environmental Setting

The Cripple Creek area is subalpine, with elevations ranging from 9,000 feet to over 10,000 feet above sea level. Elevations at the Ironclad/Globe Hill site exceed 10,000 feet and range up to about 10,400 feet. The entire mining district has experienced massive disturbance, with hundreds of mine shafts and openings and hundreds of miles of underground workings. Mine headframes dot the landscape, and there are piles of waste rock and tailings scattered throughout the mining district. Teller County has designated the entire area as an Historical Preservation Zone. As such, areas are required to retain their "mining area flavor," and this is reflected in the reclamation plans for Nerco's sites.

Many of the abandoned mine shafts and openings present a safety hazard. According to Nerco, the Colorado inactive mines program closes about 70 mine shafts and openings in the district each year. Nerco indicated during the site visit that tourists or other trespassers sometimes present a problem on their sites.

4.1.3.1 Climate

The climate is semi-arid, averaging only about 16 inches of precipitation a year. Winters are relatively dry, and snow cover is typically light. Showers and thunderstorms are common from May through September, during which 60 to 70 percent of annual precipitation occurs. Available documentation did not describe wind conditions. The 24-hour storm event with a return interval of 100 years (which mine facilities must contain) would generate about 3.5 inches of precipitation.

Winters are typically very long, and the frost-free period averages only 45 to 90 days. The mean annual temperature in the towns of Cripple Creek and Victor is about 39°F. In January, the mean minimum temperature (i.e., the average daily low temperature) is 8°F and the mean maximum is 36°F. In July, the mean minimum is 36°F, the mean maximum 72°F. Temperatures reach as low as 25 to 30°F below zero.

4.1.3.2 Surface Water

There are no perennial streams on or near the site. Mining operations, with the exception of the bottoms of waste rock dumps and the Cameron and School Section leach pads, occur on ridges and hilltops and the highest reaches of ephemeral drainages. The lower reaches of drainages, in the intervening gulches and valleys, flow only in response to rainfall and snowmelt and reach perennial streams (Cripple Creek, Fourmile Creek, and Beaver Creek) over a mile downstream. There may have been springs in many of the tributary drainages in the past, but the permeable ground surface, extensive underground workings, and deep drainage (the Carlton Tunnel) have "all but eliminated" their expression (MLRD 7/1/85).

Two gulches that are dry except in response to precipitation events drain the Globe Hill permit area (number 77-367): Poverty Gulch, which discharges into Cripple Creek in the town of Cripple Creek; and Squaw Gulch, which discharges into Cripple Creek about 1.25 miles south of the town. There was also a reservoir east of the 1977 waste dump and an emergency catch basin in the bed of Squaw Gulch, the latter intended to intercept any pregnant solution that escaped the Globe Hill pregnant pond. (Gold Resources Joint Venture, 1977) According to Nerco, these two facilities have been removed since present leach pads at Ironclad/Globe Hill drain to the east through collection ditches.

In the Victor Mine permit area (number 81-134), the mine pit, waste rock dumps, and part of the mine facilities and old tailings disposal area are in the upper reaches of Squaw Gulch. Much of the remaining Victor Mine facilities, including the old tailings disposal areas and the new Ironclad heap, are on the drainage divide between Squaw Gulch (to the west and south) and Grassy Creek (to the north and east). (Nerco 6/20/84) At least the lower reaches of Grassy Creek lie outside the Cripple Creek caldera and thus are not affected by the deep drainage of the Carlton Tunnel. Like other drainages in the area, however, Grassy Creek is not a perennial stream: in most years, it is intermittent in nature until just above its confluence with Beaver Creek about 2.3 miles down the valley (MLRD 7/1/85). During the site visit, Grassy Creek was flowing. A spill of cyanide solution in 1985 (see section 4.4.5.4) entered the Grassy Creek drainage area but did not reach the Creek itself.

Other permitted areas drain to various dry gulches and ephemeral drainages in the area. Portions of the Victory project (pads 3 and 4) and the '76 project drain to Wilson Creek. Nerco indicated that it had removed over 500,000 tons of waste rock from this drainage for use as ore on heap leach pads. Portions of this drainage appeared during the site visit to have well-established vegetation, and the creek was flowing at that time. A small wetlands area occurs in Arequa Gulch, immediately downstream of the Carlton Mill. Development of the Cresson deposit is planned in this area, and a permit under section 404 of the Clean Water Act has been issued by the U.S. Army Corps of Engineers. Water quality data for Arequa Gulch, upstream and downstream of the Carlton Mill heap leach pads, are presented in section 4.3.6.1.

4.1.3.3 Ground Water

There is little or no available ground water in the area. The Carlton Tunnel, at an elevation of about 7,000 feet, or 3,000 feet below the surface, has since 1941 drained the hundreds of underground workings that honeycomb the subsurface. (As described in section 4.4.2, the Carlton Tunnel discharges to Fourmile Creek about six miles south of the Cripple Creek area.) Prior to this, the 1907-1917 Roosevelt drainage tunnel drained much of the mining district to a depth of about 2,000 feet.

In at least some ephemeral drainages below Nerco's hilltop operations, there is shallow alluvial ground water. Below the Carlton Mill, a rancher obtains water from a well that was described by Nerco as 14 feet deep. In addition, there is perched ground water in the Grassy Creek drainage (MLRD 7/1/85). Information was not available on the quality of these alluvial ground waters, or on the presence and quality of any alluvial aquifers that may occur in other drainages.

Because of the lack of surface or ground waters in the area, Nerco obtains water for all its Cripple Creek operations from the town of Victor. This is described in section 4.3.5.3.

4.1.3.4 Vegetation

At the time of the original Globe Hill project application in 1977, vegetation on this portion of the site consisted of grasses, weeds, and forbs. The ground cover was said to be less than 10 percent, with range condition described as "poor." (Gold Resources Joint Venture, 1977) Similarly, bunchgrasses as well as various forbs and shrubs dominated vegetation on the Victor site. Trees in relatively undisturbed areas included Ponderosa and lodgepole pine, Douglas fir, blue spruce, and quaking aspen. (Silver State Mining Corporation 3/25/81, MLRD 7/1/85). Other Nerco sites were similarly disturbed before modern operations occurred, and vegetation was similar on these sites.

4.1.3.5 Soils

Predominant soils on north- and east-facing slopes are mixed Argic Cryoborolls of the "Larand" series, which consist of well drained soils on mountain sideslopes. Fine sandy loam extends to about 16 inches, underlain by about 16 inches of gravelly sandy clay loam subsoil, which is in turn underlain by gravelly sand that extends to 60 inches or more. Permeability of these soils ranges from 0.6 to 20 inches per hour, pH from 5.6 to 6.5 standard units. (Gold Resources Joint Venture, 1977) Soils of the "Quander" series are found on south- and west-facing slopes. These soils are deep, well-drained gravelly sandy and clay loam soils that formed in colluvium from mixed igneous and volcanic rocks. (Silver State Mining Corporation 3/25/81)

Nearly all of the permitted areas as well as the surrounding district have been affected to some degree by past mining activities. As a result, much of the areas's soil has been lost to erosion or otherwise disturbed. What soils existed on areas affected by current operations have been removed (to depths ranging from 1-2 inches to 12 or more, depending on how much was available) and stored in grass-seeded topsoil stockpiles. This soil will be used to support reclamation and revegetation efforts when mining operations end.

4.1.3.6 Geology

The geology of the Cripple Creek area is dominated by an alkaline volcanic diatreme that formed circa 28 million years ago during the Tertiary Period. A diatreme is a volcanic vent that is formed by gas-charged magma penetrating the surrounding country rock. The country rock is composed of jointed and faulted Precambrian igneous and metamorphic units. The volcanic complex defines the Cripple Creek mining district. The complex is composed of the Cripple Creek Breccia, a highly variable unit containing diatremal breccia and a variety of volcaniclastic derived breccias and tuffs. After the formation of the diatreme, the complex was covered and intruded by fine grain igneous rocks (phonolite flows and hypabyssal dikes). (Thompson 1992, Pontius and Butts 1991)

The larger volcanic complex is composed of three coalesced diatremes. These diatremes have been roughly identified as the North, South, and East Subbasins (Thompson 1992). The South and East Subbasins are characterized as having both vein and disseminated gold. These areas were mined since the early 1900s and include such notable units as the Cresson deposit. Within this deposit, 60,000 ounces of native gold was recovered from an open cavity (vug) 23 feet by 13 feet by 40 feet high. The Globe Hill and Victor Mines are located in the North Subbasin. Within the Globe Hill and Victor Mines, gold occurs in hydrothermal breccia deposits characterized by disseminated gold, with few veins. However, field evidence suggests that deep level vein systems are present.

The mineral-bearing hydrothermal fluid appears to have been strongly oxidizing as indicated by the gangue mineralogy. Iron and manganese oxides, sulfates (celestite $SrSO_4$, barite $BaSO_4$, and anhydrite $CaSO_4$) as well as carbonate ($CaCO_3$) are abundant in the ore body. Fine grain pyrite (Fe_2S) also occurs. It is important to note that the alkaline nature of the diatreme and the presence of carbonate minerals has resulted in relatively low potential for acid generation in the Cripple Creek area.

4.2 FACILITY OPERATIONS

As described in chapter 1 and throughout this report, Nerco's Cripple Creek operations include a number of facilities. The Ironclad/Victor mine is covered by a single Mined Land Reclamation Division (MLRD) permit (number 81-134), and the adjacent and contiguous Globe Hill operation by another (number 77-367). The two permits previously covered two entirely separate facilities operated by different companies. Nerco has consolidated the operations under these permits into the "Ironclad/Globe Hill" operation, but the areas continue to be covered by separate MLRD permits. Currently, Nerco's new "Ironclad" heap leach pad (see below and section 4.3.5) covers parts of both permit areas.

This chapter describes Nerco's current mining (section 4.2.1), heap leaching (section 4.2.2), and gold recovery (section 4.2.3) operations on the Ironclad/Globe Hill site. Previous operations that took place on these permit areas, and more details on the facilities (as opposed to operations), are described in chapter 4.3. Chapter 4.3 also describes both operations and facilities at several of Nerco's other Cripple Creek operations. Except as specifically noted, all information in this chapter was obtained during the site visit. Figure 3-3

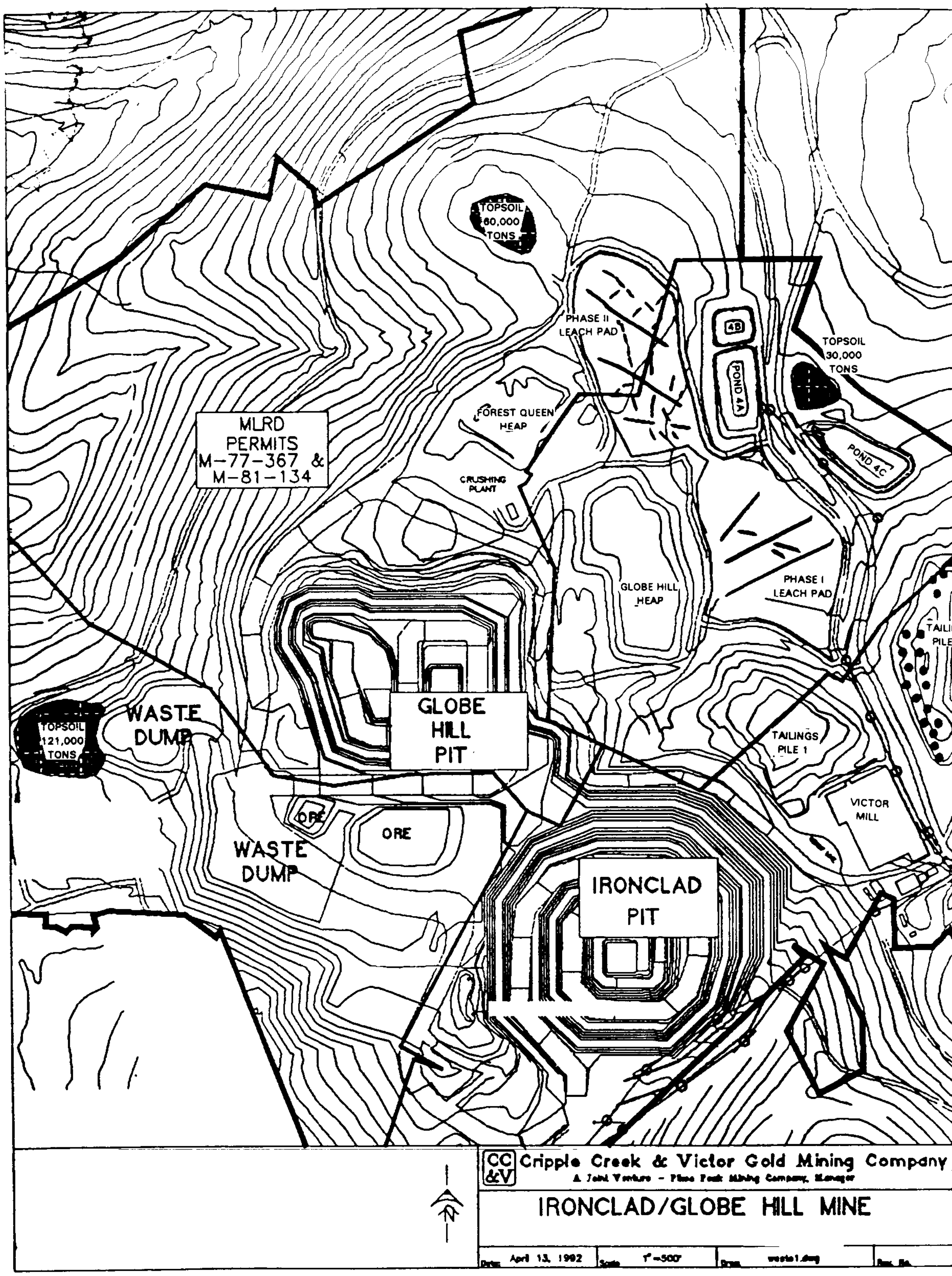


Figure 4-3. Location of Ironclad/Globe Hill Facilities (MLRD Permits 77-367 and 81-134)

(Source: Provided by Nerco during site visit, with additional labels added by EPA) shows the location of the various facilities on the Ironclad/Globe Hill site.

4.2.1 Mining Operations

The Ironclad/Globe Hill facility mines ore from two open pits, the Ironclad and Globe Hill pits. The Globe Hill pit (MLRD permit 77-367) is on a southwest slope near the top of Globe Hill. The pit has reached a depth of 80 feet, measured from the uphill highwall to the pit floor; the site visit team estimated the depth on the downhill side at about 50 feet. Plans are for the pit to reach a maximum depth of about 200 feet. Ore from the Globe Hill pit has been leached in heaps since the original permit was issued in 1977, first on two heap leach pads (the Forest Queen/2A and Globe Hill pads—see section 4.3.3) and now on the Ironclad pad (see sections 4.2.2 and 4.3.5.1).

The Ironclad pit (permit 81-134) is adjacent to the Globe Hill pit, a distance of less than 0.5 miles. The current pit encompasses part of a previously mined pit that was active around 1904 and the 1930s (Silver State Mining Company 3/25/81). Ironclad also was mined as a glory hole in the 1940s, when manganese and possibly other ores were mined. Since being mined for disseminated gold ore beginning in 1981, the pit has reached a depth of about 200 feet, measured from the uphill highwall to the floor; the site visit team estimated the depth on the downhill side at 50 to 75 feet. Openings to numerous underground workings that have been intersected by the pit were observed during the site visit. The uphill wall of the pit has a slope of about 60 degrees; according to Nerco, this slope is extreme but has remained stable. During the site visit, it appeared that only minor sloughing had occurred. Formerly, ore from the Ironclad pit was leached in vats, as described in section 4.3.4; ore is now leached on the Ironclad pad.Rock in the pits is drilled on 15-foot centers, and each hole is assayed to direct mining operations. Flags of different colors are used to identify material as waste rock or ore prior to removal. The cutoff grade between waste rock and ore is 0.015 Troy ounces of gold per ton of rock (i.e., material with greater than 0.015 Troy ounces of gold per ton of rock is considered ore and material with less is waste rock). Ammonium nitrate/fuel oil (ANFO) is used as the blasting agent, with an unspecified emulsion used when holes are wet. The pits are mined on 20-foot benches. A total of about 45,000 tons of material per day are mined, with approximately half coming from each pit. About 8,000 to 15,000 tons of mined material are ore and 30,000 to 37,000 tons are waste rock. The stripping ratio, according to Nerco, typically ranges from 2.7:1 to 3.0:1 (i.e., 2.7 to 3.0 tons of waste rock per ton of ore).

Caterpillar 992 loaders with capacities of 12.5 cubic yards load blasted waste rock or ore into 85-ton Caterpillar 777 haul trucks. The trucks haul waste rock to the waste rock dump, which extends along the hillsides immediately adjacent to and between the pits. Much of the haulageway from the pits to the edge of the pile traverses the top of the waste rock pile. Rock is dumped over the edge at an angle of repose of about 1.35 horizontal to 1 vertical (about 37 degrees). At the base of the pile, Nerco maintains a berm to contain stray rocks and boulders. Periodically, the addition of waste rock advances the toe of the pile farther downslope into the ephemeral drainage. Before this occurs, Nerco is required to strip and store topsoil before waste rock is allowed to impinge on those areas. At the time of the site visit, the dump contained a total of about 5,000,000 tons of waste rock. In addition, about 121,000 tons of topsoil were in a stockpile near the dump (see Figure 4-3).

Ore is transported in the haul trucks out of the pits to one of two unlined stockpiles. One stockpile, which contains about 300,000 tons of ore, is located between the Globe Hill pit and the edge of the waste rock dump; ore from the two pits is kept separate in this pile. The second stockpile, of undetermined size, is near the jaw crusher. This area is located on the hilltop immediately above the pits, a distance of less than one-half mile. In the crusher stockpile, ore with relatively high clay or fines content is kept separate from other ore (the clay cutoff was not determined). Loaders blend the fine and coarse ore (to maintain a consistent feed to the crusher) and move the ore the short distance (less than 100 feet) from the stockpile to the jaw crusher.

The crusher and conveyor systems are operated by a contractor, Nordic Industries. Ore is crushed (at an unspecified rate) in a primary jaw crusher to a nominal diameter of less than three inches and passed over a one-inch screen. Fine (less than one inch) and coarse materials are placed on separate, parallel conveyors (the proportions greater than and less than one inch were not determined). The fine ore is agglomerated with cement at a rate of seven pounds of cement per ton of ore. This agglomerated ore is then combined with the coarse ore on a third conveyor. On the consolidated conveyor, lime is added to raise pH (five to seven pounds of lime per ton of ore). Cement and lime are added from storage silos that straddle the respective conveyors; the sizes of the silos were not determined. In addition, a sodium cyanide solution (about 0.25 pounds of sodium cyanide per ton of solution) is added to ore on the conveyor to raise the moisture content to about six percent (compared to the mined ore moisture of about four percent) and initiate leaching. The means by which cyanide solution is conveyed from the barren solution tanks in the mill building to the conveyor was not determined, but it appeared that the solution was distributed along the conveyer in otherwise unprotected rubber hoses about 0.5 to one inch in diameter. The conveyor transports the ore from the crushing area to the appropriate cell on the Ironclad leach pad, where ore is stacked on the heap.

During the site visit, it was noted that ore fallen from the conveyors in the crusher area (both before and after cyanide addition) had reached a depth of one to two feet under the conveyors. Workers were observed shoveling some of this stray ore back onto the conveyor. Most of the stray ore appeared to be relatively fine material.

4.2.2 Leaching Operations

As described in more detail in section 4.3.5, the Ironclad heap leach pad system is being constructed in three phases, with the first phase begun in 1991 and the final phase completed in 1992 (see Figure 4-3). When complete, the new pad will cover about 1,500,000 square feet and will contain about 4,400,000 tons of ore (see Figure 4-4

Figure 4-4. Planned Final Configuration of Ironclad Heap

(Source: Nerco 5/10/91, with additional labels added by EPA)

for the planned final configuration of the Ironclad heap). As construction proceeds, sections of the various phases of construction are being placed in operation and actively leached. By early 1992, portions of the Phases I and II pads had been completed and leaching had begun (see section 4.3.5); these will become part of the single large Ironclad heap when Phase III is complete in 1992. The amount of ore that has been placed on these sections to date was not determined.

Ore is stacked in 20- to 30-foot lifts (based on MLRD inspection notes rather than other descriptions) and will reach a final height of over 100 feet (based on contour maps, not on narrative descriptions in available documentation). Maximum side slopes, and whether these are specified by MLRD, were not described.

Barren solution is made up in three 60,000 gallon tanks in the mill building. According to Nerco, barren solution has a cyanide concentration of 80 to 100 parts per million (ppm) and a pH between 11.5 and 12. Milsperse 802 is added to barren solution as an antiscalant (the rate and amount added were not known). Solution is pumped to the pads and applied via drip irrigation pipes to 80,000 square foot active leaching cells at a rate of about 400 gallons per minute (gpm), or 0.005 gallons per square foot per minute. Leaching raises the moisture content of the ore from about six percent to about 15 to 18 percent. The length of time each subcell is leached was not determined. Leaching occurs year-round, unlike many previous heap leach operations in the Cripple Creek area. According to Nerco, there may be occasional freezing in solution lines when temperatures are very low. Nerco indicated that on one occasion, an overnight power outage resulted in about 70
percent of the solution lines freezing. All had thawed and were operational by noon the following day, with no apparent ill effects.The heap leach pads are double-lined (80-mil HDPE primary upper liner over 60-mil HDPE secondary lower liner, with a leak detection system between the liners--see section 3.5 for detailed descriptions of pad and pond construction). Pregnant solution is collected in eight-inch diameter slotted HDPE pipes placed beneath the ore on the upper liner; solution drains from the pipes to collection ditches that extend along the downslope sides of the pads (on the north and east of the Phase I pad, on the west of the Phase II pad). As described in section 4.3.5, ditch liners are simply extensions of pad liners. Solution is conveyed to a stilling basin, which slows the flow before solution is directed to the pregnant solution pond or, if necessary, an emergency overflow pond. All ponds are double-lined, with two 60-mil HDPE liners and a geotextile leak detection system between; pond construction is described in detail in section 4.3.5. The total capacity of the three solution ponds is 10,000,000 gallons, sufficient to hold working solution and run-off from the 100-year/24-hour storm. Pregnant solution, as pumped to the Victor Mill building, has a pH of about 11.

4.2.3 Gold Recovery Operations

Gold recovery operations occur in the Victor Mill building, which also contains the vats formerly used for leaching (see section 4.3.4). Pregnant solution is pumped from the Ironclad solution ponds to the mill building, where gold is recovered from the pregnant solution in two carbon-in-column circuits. Each circuit consists of four portable columns (each "column" is an enclosed tank or vessel) that operate in series. Each column in a four-vessel series contains 1.0 to 1.25 tons of activated carbon. The size of the columns was not determined, but they appeared to be about 15,000 gallons. Pregnant solution is pumped at a rate of 250 to 400 gallons per minute into the bottom of the first column, up through the carbon, and out through pipes at the top. Similarly, it is pumped to and through the other three columns in series. When solution exits the top of the fourth column, it is directed to one of three 60,000-gallon barren solution makeup tanks, which are also located in the mill building. Nerco periodically assays the tails solution from each column. When the gold concentration rises to some unspecified level, which indicates that the carbon is no longer adequately adsorbing gold, a column with fresh carbon is substituted in the train.

Loaded carbon is removed from the columns for further processing (as described below) and replaced with fresh carbon. According to Nerco, it typically takes three to four days for carbon in a column to become fully loaded, but this can take up to a month. Nerco has a total of 32 portable columns; at the time of the site visit, eight were in use at the Ironclad/Globe Hill site in two parallel circuits and four at the Carlton Mill Pad 2 [see section 4.3.6.1]. The other twenty are held in reserve as replacements for columns with loaded carbon and presumably for Cresson operations when they begin. (When columns at Carlton Mill Pad 2 are loaded with gold, a fresh column is substituted in the train and the column with loaded carbon is transported to the Victor Mill in a specially designed truck. Prior to January 1992, columns were transported to the Carlton Mill for gold recovery and carbon regeneration).

Gold is desorbed (stripped) from the loaded carbon with a caustic wash (one percent sodium hydroxide, one percent sodium cyanide) in one of two enclosed tanks (the size was not determined, but they appeared to be about 50,000 gallons each). The strip circuit is operated at 240°F, at a pressure of 50 pounds per square inch. Stripped carbon is then acid-washed with hydrochloric acid, regenerated in a propane-fired Allis-Chalmers horizontal kiln, and quenched with water before storage and reuse. According to Nerco, spent acid and quench water are returned to "process water ponds" (presumably the pregnant solution pond)—the amounts of fresh acid and reactivated carbon stored on-site were not determined. Carbon fines are shipped off-site for gold recovery: the point in the process at which carbon is screened to remove fines was not determined, but Nerco indicated that they generate about one barrel of fines per year. The facility uses about 50 tons of carbon per year. Spent carbon is shipped off-site with the carbon fines.

The gold-laden caustic solution goes to an electrowinning cell (the number and sizes of cells were not determined). A stainless steel woven wire cathode (steel "wool") acts as the cathode onto which gold is plated (along with small amounts of silver). The steel wool is then removed, washed with high-pressure water, and filtered. The filter cake is then placed in a propane-fired tilt furnace, where gold is melted off the steel wool to produce doré (a conventional flux also is used in the furnace). A wet scrubber is used to control furnace emissions. According to Nerco, significant (but unspecified) amounts of gold are recovered from scrubber sludges, which are sent off-site for gold recovery about once a year; the volume of sludges shipped was not known. (Since the Ironclad leaching operation only began operation in early 1992, it is not clear if the reported volumes and frequency of removal of carbon fines and sludge were estimated for the future or are based on Carlton Mill operations for the previous year.) Overall, Nerco reported that from 70 to 85 percent of soluble gold in mined ore is recovered.

4.3 MATERIALS AND WASTE MANAGEMENT

Chapter 4.2 described operations on the Victor Mine and Globe Hill permit areas, the consolidated "Ironclad/Globe Hill" site. This site was the primary focus of the site visit. Sections 4.3.1 through 4.3.5 of this chapter describe the facilities on these permit areas and the wastes and materials that are managed there by Nerco. Figure 4-3 showed the locations of facilities described in these sections. Active facilities are described in sections 4.3.1, 4.3.2, and 4.3.5. An understanding of previous operations on the site is necessary in order to understand current operations and also to allow the complexity of the site to be conveyed; in addition, wastes generated by previous operations remain on the site. For these reasons, previous operations and facilities on these permit areas are described in this chapter (in sections 4.3.3 and 4.3.4). Finally, section 4.3.6 describes a number of Nerco's other Cripple Creek operations.

4.3.1 Mine Pits

The Ironclad/Globe Hill operation currently mines ore from two open pits, the Globe Hill and Ironclad pits. As described in Chapter 4.2, the Globe Hill pit has reached a depth of 80 feet and plans are to continue to a final depth of about 200 feet. The Ironclad pit has reached 200 feet and plans are to continue to a final depth of about 400 feet (the areal extent of the two pits was not determined). Ore from the two pits is commingled at the crusher plant. As noted in section 4.2.1, the Ironclad pit has intercepted a number of underground workings, which are clearly visible in the highwalls; none were observed in the Globe Hill pit, but they may be encountered as the depth of the pit increases. At the Ironclad pit, tailings from historical mining operations were being encountered by mining operations and were observed during the site visit.

Ground water has not been and is not expected to be encountered in either pit, since the ground-water regime to a depth of about 3,000 feet (to an elevation of about 7,000 feet above sea level) is dominated by drainage to the Carlton Tunnel. There is little or no upslope area from which run-off drains into the pits, and the only water that accumulates in the pit is from direct precipitation. Any such accumulation evaporates and has not required pumping or other removal to date.

Reclamation requirements for the Globe Hill pit include leaving a safety or warning drop bench no more than 15 feet below the top of the pits (Silver State Mining Corporation 3/25/81, MLRD 9/8/81). In the Ironclad pit, a 20-foot-wide drop bench will be left about 20 feet below the pit's rim (Nerco 6/19/84). Final pit walls in the Ironclad pit may be benched at 30-foot intervals, with a final slope of 45 to 55 degrees (this was not described for the Globe Hill pit). There will be a ramp into each pit to increase pit wall stability and to allow exit by trespassers and wildlife. The ramps will be blocked by berms or boulders to discourage access. The pits will be fenced and appropriate warning signs posted. Overall, the pits are to be left rough-graded "without conical peaks or trench-like excavations," but will not be revegetated, except for the benches and pit floors. This will allow the pits to meet Teller County zoning requirements that the area retain its "mining area flavor." (Silver State Mining Corporation 3/25/81, MLRD 9/8/81, Nerco 6/19/84)

Haul roads from the pits to the waste dump (which are constructed on and across the dump) and to the stockpile in the crusher area will be reclaimed by smooth-grading to slopes between three and five horizontal to one vertical (3H:1V to 5H:1V), then mulching and revegetating with grasses and trees (Silver State 3/25/81, MLRD 9/8/81).

4.3.2 Waste Rock Dump

Waste rock from the pits is taken by truck directly to the mine dump, which is on the hillside on the east and north slopes of Poverty Gulch and Squaw Gulch immediately adjacent to the pits. As described in Chapter 4.2, a total of about 45,000 tons of material was being mined per day at the time of the site visit, of which 30,000 to 37,000 tons were waste rock. About 5,000,000 tons of waste rock had been disposed in the dump at the time of the site visit (since 1981, when the Victor Mine permit was issued). The total area covered by the waste rock dump was not determined. At least a portion of the dump on the Ironclad/Victor permit area is located in an area covered by mine dumps that predate the modern operations. The waste rock dump used on the Globe Hill before operations were consolidated is apparently located immediately to the north of the Globe Hill pit; at least one area of this dump was used to dispose of triple-rinsed and crushed barrels in which cyanide was received (MLRD 9/28/84). The amount of waste rock in the Globe Hill dump was not determined.

There is little or no upslope area to contribute run-on, so run-off comes only from direct precipitation on the surface of the dump itself (the top of which is fairly extensive and serves as the haulageway from the pits). References in permit correspondence seemed to refer to one or more sedimentation ponds at the base of the dumps (MLRD 3/21-22/85, Nerco 1/87). According to Nerco, a sedimentation pond remains in place at the base of the dumps. No information was obtained on whether run-off or other storm water discharges have ever been monitored, either at the base of the piles or in the ephemeral drainage of Poverty Gulch. As described in section 4.3.3 and 4.3.5 below, Nerco plans to "detoxify" spent ore on two old heap leach pads (the Globe Hill and Forest Queen/2A pads) and place it on the waste rock dump. It was not determined if the spent ore has a higher proportion of fines than the waste rock and thus could contribute additional loadings to run-off.

To date, only oxide ores have been encountered and acid generation potential of waste rock was described by Nerco as very low; no other information on acid generation or neutralization potential was obtained. As the Ironclad pit increases in depth, Nerco expects an increase in the sulfide content of ores and waste rock. Actions to be taken by Nerco or MLRD when this occurs had not been determined at the time of the site visit.

Waste rock is end-dumped on the pile at the angle of repose, about 1.35H:1V (about 37 degrees). A geotechnical engineering study by Nerco's consultant found this slope was stable under normal conditions, and that only minor sloughing would occur in the event of "unlikely" earthquakes (Dames & Moore 1984). The dump appears to be about 250 feet high. In 1984, gradational analyses of uncrushed run-of-mine material indicative of Ironclad pit waste rock showed over 60 percent less than one inch in diameter, with 35 to 45 percent less than one-quarter inch (Nerco 6/19/84).

At the foot of the dump, Nerco is required by MLRD to maintain a berm to intercept errant boulders that are dumped over the edge. As the dump grows, the base of the dump will continue to be extended outward. Nerco is required to remove topsoil from areas to be affected by the dump. Topsoil is stored, and seeded with grasses, in one or more stockpiles at the base. One stockpile, immediately west of the Globe Hill pit, contains 121,000 tons of topsoil. The topsoil will be used during reclamation.

Original reclamation plans were for the waste rock dumps to be left rough-graded without conical peaks or trench-like excavations in order to retain the "mining area flavor." It was not clear whether the surface would be covered with topsoil and revegetated. (MLRD 5/22/86 and 9/8/81) However, reclamation plans for the Ironclad dump call for the upper surfaces of the dump to be graded and sloped away from the edge in order to prevent erosion; to minimize infiltration, Nerco may use downcomers or other conveyances to remove precipitation. At the Ironclad waste dumps, stockpiled topsoil will be used to aid in revegetation (Nerco 6/19/84), although details on the use of test plots and final planning were not available. Reclamation requirements for the Globe Hill dump include rough-grading as well. The upper surface of this portion of the dump is to have a two to three percent "dome-like" surface to minimize ponding and infiltration. The maximum outer slope is to be 1.5H:1V. Revegetation is apparently not required on the top or slopes. (MLRD 5/22/86)

In 1990, Nerco advised MLRD of its intent to provide two truck loads of waste rock in a pilot test of its use as an aggregate for asphalt or other uses. Evaluation and testing were to occur in Colorado Springs. (Nerco 9/11/90) The results of any such testing, if it occurred, were not determined.

4.3.3 Heap Leach Pads and Ponds, Permit 77-367 (Globe Hill Projects)

As noted elsewhere, the Ironclad/Victor Mine and Globe Hill projects are in reality a single project, although they currently are permitted separately. The separate permits are an artifact of their histories prior to Nerco's consolidation of the operation. The heap leach pads and ponds described in this section are not currently active; they are described in order to indicate the complexity of the site, because they remain on the site, and because they will be affected by current Ironclad/Globe Hill operations. Because the heaps are no longer being leached, the spent ore on the heaps are wastes.

4.3.3.1 Globe Hill Pad and Ponds

One of the first cyanide heap leach projects in Colorado and the west, this pad was originally permitted, in 1977, at about four acres, measuring 350 by 500 feet (Gold Resources Joint Venture 1977). Amendment 1 to the permit added another four acres to the pad (Gold Resources Joint Venture 1978). This brought the total dimensions to roughly 800 by 400 feet (the pad is not rectangular), about eight acres overall. Other than a Nerco report that the liner consisted of 18 inches of old tailings from an area mill, information on pad site preparation and construction was not obtained (Nerco 2/12/86).

The original pregnant pond for this pad was initially 120 by 100 feet, about 0.28 acres (Gold Resources Joint Venture 1977). Another 1.44 acres was added in 1978, making the pregnant pond's dimensions 375 x 200 feet, an area of 1.72 acres (Gold Resources Joint Venture 1978). Information on the pond's capacity was not obtained, nor were descriptions of the liner system (if any) and pond construction. No information was obtained on the barren pond, if there was one.

Ore came from the Globe Hill pit and apparently was not crushed after blasting (Gold Resources Joint Venture 1978). In addition, waste rock from various underground mine dumps in the area may have been used as ore. Information on the means by which barren solution was prepared and stored and by which pregnant solution was conveyed to the pond and processing facilities was not presented in the permit application or other available reports and correspondence. Similarly, information on the processing facilities themselves was not obtained.

When active leaching ended, reclamation requirements were to rinse the heap with fresh water, followed by an oxidant if cyanide was still detectable. The surface of the heap was to be rough-graded without conical peaks or trench-like excavations, but not revegetated. The pregnant pond was to be backfilled and revegetated. (Gold Resources Joint Venture 1978; MLRD 5/22/86) The period of time in which the Globe Hill heap actually received ore and was actively leached, and when active leaching ended, could not be determined from available documentation. Nerco reported in 1986 that the heap's slopes ranged from 1.6 to 1.8 horizontal to 1 vertical (Nerco 2/12/86). The operation's "stripping plant" (not otherwise described) was dismantled in 1984 in preparation for the construction of a vat leaching operation similar to Nerco's adjacent operation (described in section 4.3.4) (MLRD 7/1/85); the vat leaching plan was never implemented. It was not determined if the "stripping plant" and other gold recovery operations were replaced or if other facilities (e.g., Nerco's adjacent plant) were used thereafter.

A number of samples of Globe Hill pond liquids were taken in 1985 and later years. Although available documentation is not explicit, it is believed the liquids in the pond represented run-off and precipitation-induced seepage, not active leaching solutions. Sampling results are presented in Table 4-1.

In 1984, the Globe Hill heap and pond were conveyed from Newport Minerals' permit 77-367 to Nerco's

Table 4-1. Concentrations of Selected Parameters in Globe Hill Heap Pond

(milligrams per liter, unless otherwise indicated)

Parameter	Date				
	4/9/85[a]	7/19/85[b]	6/86[c]	1/20/89[d]	9/15/89[d]
pH (s.u.)	NR	NR	9.53	4.14*	4.85*
TDS	NR	NR	NR	6,840	4,180
Total CN	0.044	NR	0.0025	0.17	0.081
Free CN	NR	NR	NR	0.04	< 0.05
Radium 226 (pCi/L)	NR	NR	NR	NR	2.1 (+/- 1.6)
Nitrate	NR	NR	NR	190	113
Arsenic	0.005	0.005	NR	< 0.001	< 0.002
Copper	0.07	0.44	0.03	1.72	0.57
Lead	NR	NR	NR	0.12	0.22
Silver	0.001	0.020	0.001	0.01	< 0.01
Sulfate	575	2,350	NR	3,440	2,480
Zinc	NR	NR	0.011	5.57	3.02

NOTES:
- NR Not reported
- * Nerco (3/30/89) speculated that the low pH was attributable to prior effortsto meet reclamation requirements. (Information on these efforts was not available.)

Sources:
- a Newport Minerals 6/24/85
- b Newport Minerals 9/24/85
- c Newport Minerals 7/18/86
- d Table G-1 in Nerco 9/89 (1989 Annual Report to MLRD). January samples taken under 14 inches of ice.

Victor Mine permit 81-134. At that time, plans were to cover at least part of the heap with a 20-mil PVC liner and tailings from the Victor vat leaching operation; Nerco requested MLRD to specify decommissioning requirements for the pad before this occurred. (Nerco 6/19/84, 4/25/85) "Environmental responsibility" for the pond (and possibly the pad as well) apparently was to remain with the Globe Hill operator until Nerco actually used the area for tailings disposal (Nerco 3/30/89). Whether MLRD provided decommissioning specifications was not determined, and apparently tailings were never placed on the Globe Hill heap. In

1991, Nerco (actually, Pikes Peak Mining Company) took over this permit as well, and now has full responsibility for all facets of the Globe Hill permit.

In 1991, Nerco developed plans to construct the Ironclad heap leach pad, covering portions of the Victor Mine and Globe Hill permit areas (i.e., both permits 81-134 and 77-367). Phase III of this project, planned to be completed in 1992, is the construction of a double-lined leach pad where the Globe Hill heap is located (see section 4.3.5.1). Nerco indicated in the application that the Globe Hill pad would be "detoxified" before being graded for use as a base for the new pad. (Nerco 5/10/91 and MLRD 10/10/91) During the site visit, Nerco indicated that the heap would be rinsed with water and, if necessary, an oxidant, until cyanide levels were below 0.2 ppm (whether free, total, or weak-acid-dissociable cyanide was not specified). Following this, spent ore from the heap would be placed on the waste rock dump. It was not determined if this detoxification had begun or had been completed (or even if it would be necessary, since free and total cyanide levels were well below 0.2 ppm in 1989, as shown in Table 4-1).

4.3.3.2 Forest Queen/2A Heap Leach Pad(s) and Pond(s)

Sometime prior to September 1981, Newport Minerals constructed two additional heap leach pads within the Globe Hill permit area, the Forest Queen and 2A pads, and began leaching the Forest Queen heap. The pads were located on the surface of Globe Hill waste rock dump.

The only descriptions of pad site preparation that were obtained were in MLRD correspondence to and from another mining company (there were none in the permit application or related documentation). This correspondence noted that the pads did not have synthetic liners or leak detection systems, but were constructed on 18 to 24 inches of compacted tailings (Reilly 4/6/86; MLRD 5/22/86). The pond(s) apparently were lined, since in 1986 MLRD issued Newport a Notice of Violation for degradation of the Forest Queen/2A pond liners (MLRD 7/1/86). Other information on the ponds' liner system and pond construction was not obtained. Similarly, no information was available on pond capacity.

Ore for the Forest Queen/2A pad(s) came from the Globe Hill pit and/or from waste rock dumps from various underground mines that had operated in the area. As with the Globe Hill heap leach pad, the permit application and other available documents do not describe the means by which barren solution was prepared and stored and by which pregnant solution was conveyed to the pond and processing facilities. Similarly, information on gold recovery operations was not available.

Also similar to the Globe Hill pad, the period of time during which the Forest Queen/2A heap received ore and was actively leached, and when active leaching ended, could not be determined from available documentation (except, as noted above, that the "stripping plant" was dismantled in 1984). It is known that in later years, the Forest Queen and 2A heaps had become a single heap, known variously as the Forest Queen, 2A, or Forest Queen/2A heap.

Although available documentation is not explicit, it is believed the ponds contained only run-off and precipitation-induced seepage, not active leaching solutions. Results of two sampling events, in 1985 and 1986, are presented in Table 4-2; later data were not obtained.

Table 4-2. Concentrations of Selected Parameters in Forest Queen/2A Heap Pond

(milligrams per liter, unless otherwise indicated)

Parameter	Date	
	7/19/85[a]	6/86[b]
pH (s.u.)	NR	10.518
TDS	NR	NR
Total CN	NR	0.0025
Free CN	NR	NR
Radium 226 (pCi/L)	NR	NR
Nitrate	NR	0.06
Arsenic	0.007	NR
Copper	0.03	0.051
Lead	NR	NR
Mercury	0.0013	0.005
Silver	0.011	0.01 (oz/ton)
Sulfate	3,850	210
Zinc	NR	0.008

NR Not reported

SOURCES:
- a Newport Minerals 9/24/85
- b Newport Minerals 7/18/86

Reclamation requirements for the Forest Queen/2A heap(s) included rough-grading to exclude conical peaks or trench-like excavations, but not revegetation since the area was to retain its "mining area flavor." Pond solution was to be circulated and evaporated to reduce volumes. In addition, the heaps were to be rinsed with fresh water, followed by an oxidant if cyanide remained. At cessation of operations, ponds were to be sampled for at least a year; when heap effluent (from run-off and infiltration of precipitation) became "similar in nature to the fluids naturally occurring in [Cripple Creek or Wilson Creek]...downstream," the operator could remove the ponds and fences, then grade and revegetate the pond area. (MLRD 5/22/86; Geddes et al. 11/25/81) In 1985, the ponds associated with the Forest Queen/2A heap were removed from the Newport permit (77-367) and were apparently conveyed to Nerco Minerals, the operator of the adjacent Victor Mine (permit 81-134) (MLRD 7/1/85).

Dayspring Mining Corporation, which succeeded to Permit 77-367 in 1986, indicated in 1988 that neutralization of the "Forest Queen pads" had been completed (Dayspring Mining Corporation 3/17/88). How this was accomplished was not described. As described in detail in chapter 4.2 above and section 4.3.5 below, Nerco (actually, Pikes Peak Mining Company, which succeeded Dayspring as the permittee in 1990) was constructing a large heap leach pad that will cover portions of Victor Mine and Globe Hill property (i.e., both permits 81-134 and 77-367). Phase II of this project, partially completed by early 1992, is the construction of a double-lined leach pad that covers the area where the Forest Queen/2A heap is currently located. In the permit amendment, Nerco indicated that the Globe Hill pad would be "detoxified" before being graded for use as a base for the new pad. (Nerco 5/10/91, MLRD 10/10/91)

During the site visit, Nerco indicated that the heap would be rinsed with water, and possibly an oxidant, until cyanide levels were below 0.2 ppm; when this is accomplished, the "detoxified" spent ore will be placed on the waste rock dump. It was not determined if this detoxification had begun or had been completed (or whether it would be necessary, since Table 4-2 suggests that cyanide levels may be below that level). Leaching of at least one subcell of the Phase II heap, a subcell not located on the Forest Queen portion of the new pad, had begun by early 1992 (see sections 4.2.2 and 4.3.5.1).

4.3.4 Victor Tailings Piles and Previous Vat Leach Operation (Permit 81-134)

From the time of initial Victor Mine operation in 1981 until a cessation of operations that began in early 1986, the facility operated a vat leach system. As noted previously, Silver State Mining Corporation was the original owner/operator; Nerco became the operator in 1984 when it purchased Silver State (Silver State 4/13/84, MLRD 6/20/84).

Ore from the Ironclad pit was crushed to 0.5 to 1.0 inches in diameter. Portland cement was added at a rate of about 10 pounds per ton of ore and a concentrated solution of sodium cyanide and caustic soda (concentrations were not provided but the reagents amounted to about one percent by weight) was also added. Cement and reagents were added to the ore in an agglomerating drum. Ore was then conveyed to a stockpile in the Victor Mill building, from which it was transported by loader to one of four 1,000 ton indoor vats (each 80 x 50 x 9 feet). The vats were constructed of 9.5 inch rebar-reinforced concrete and had a sloping base to facilitate loading and unloading. Rubber waterstops were used to fill concrete joints and the insides of the vats were periodically re-sealed with epoxy. (MLRD 9/8/81, Lewis 1982, and Nerco 4/25/85)

Once placed in a vat, ore was saturated with a solution containing 2.5 pounds of sodium cyanide per ton of solution (0.1 to 0.12 percent free sodium cyanide). Pregnant solutions drained through the ore into sumps, then were pumped to the processing facilities elsewhere in the mill building. After leaching, but before removal from vats, ore was rinsed with fresh water and drained for at least two hours, after which time the "tailings" were removed by front-end loader and placed on a conveyor, which carried them to the tailings pile.

On the pile, a bulldozer or loader spread tailings on the top and over the advancing face of the pile. Unloading and conveyance gave the tailings another four to six hours to drain residual solution. The vats operated on three- or four-day cycles and at any given time, two vats would be leaching while the other two were being loaded or unloaded. Gold recoveries were said to be about 83.6 percent. (MLRD 9/8/81, Lewis 1982, Nerco 2/12/86)

The spent ore, or tailings, was placed in free-standing tailings piles, one (area 1) immediately to the north of the mill building and a second (area 2) across Range View Road immediately to the northeast. The piles were lined with 20-mil PVC and surrounded by berms. In some areas, the liner was placed on 12 inches of fine-grained (but otherwise undescribed) material; in later years, a 90-mil (300-grade) geotextile fabric was substituted as an underlayer. Drainage from at least some areas of the piles was facilitated by four-inch pipes installed over the liner. (Silver State Mining Corporation 3/25/81 and 5/24/83; MLRD 9/8/81 and 2/26/87; Nerco 5/9/85 and 1/6/87) An extension of tailings area 1, located partially on top of the old Globe Hill heap, also was planned, but apparently was never implemented (Nerco 6/19/84, 4/25/85, and 2/12/86; MLRD 6/11/85).

Tailings, which were dumped at their angle of repose, were set back about 12 feet from a berm that was (or is) four feet high. The liner extended out from the toe of the pile to the top of the berm, and this area served as a seepage/run-off collection ditch; in the downhill corner, a larger area served as a collection pond. As the tailings area advanced downhill and the liner was extended, the collection ponds were advanced as well. Thus, as the tailings piles changed configurations over time, the collection ponds also changed locations and sizes. This culminated in most of area 1 draining to a permanent pond some distance downhill from (and north of) the tailings; this pond was lined with 36-mil Hypalon. This pond, known as pond 4A, was later enlarged and relined for use as the pregnant solution pond for the new Ironclad heap leach (see section 4.3.5.2). (Silver State Mining Corporation 3/25/81; MLRD 9/8/81 and 2/26/87; Nerco 2/12/86 and 1/6/87) In 1987, during the extended shutdown, a second Hypalon-lined pond was constructed below the first one and provided additional capacity; this pond became Pond 4B, as described in 4.3.5.2 below (Nerco 9/87, 5/10/91).

A portion of area 1 drains to pond 1 South, which is located inside the surrounding berm; the size and capacity of this pond were not determined. Ponds 2 South and 2 North (of undetermined size and capacity) receive drainage from area 2. How solutions in the ponds were managed prior to 1984 was not determined (i.e., whether processed for gold recovery, land-applied, or used as barren solution makeup water). In 1984, after succeeding Silver State as the operator, Nerco indicated that solutions would be removed "as necessary" and used as process water (Nerco 6/19/84).

Following Nerco's assumption of the Victor Mine permit (81-134), solutions in the tailings collection ponds were sampled for pH and cyanide monthly and for a full suite of parameters annually. Table 4-3

Table 4-3. Concentrations of Selected Parameters in Tailings Collection Ponds

(units are milligrams per liter except as noted)

Parameter	10/30/87	9/10/88	9/15/89	8/23/90
Pond 4A[a]				
pH (s.u.)	9.31	9.97	9.69	8.6
TDS	474	520	444	550[b]
Total CN	0.61	0.006	0.131	0.1
Free CN	0.02	< 0.1	< 0.05	< 0.1
Radium 226 (pCi/L)	9.4	-	15	8.2
Nitrate	11.5	6.95	7.0	0.19
Arsenic	0.028	0.024	0.033	0.006
Copper	0.55	0.28	0.26	0.053
Lead	0.68	0.6	0.59	0.019
Silver	0.05	0.01	< 0.01	0.0003
Zinc	0.93	0.85	0.75	0.072
Pond 4B[a]				
pH (s.u.)	9.58	8.48	8.35	8.3
TDS	440	348	385	360[b]
Total CN	0.51	0.051	0.068	0.046
Free CN	0.01	< 0.1	< 0.05	< 0.1
Radium 226 (pCi/L)	8.9	-	7.8	3.3
Nitrate	14.7	7.63	8.1	2.0
Arsenic	0.013	0.015	0.017	< 0.005
Copper	0.44	0.18	0.27	0.039
Lead	0.48	0.25	0.61	0.031
Silver	0.05	0.01	< 0.01	0.0003
Zinc	1.02	0.39	0.51	0.082

(continued)

Table 4-3. Concentrations of Selected Parameters in Tailings Collection Ponds (continued)

Parameter	10/30/87	9/10/88	9/15/89	8/23/90
Pond 1 South[a]				
pH (s.u.)	9.03	9.45	10.0	10.1
TDS	666	400	636	780[b]
Total CN	0.4	0.559	0.299	0.54
Free CN	0.04	< 0.1	0.14	0.14
Radium 226 (pCi/L)	15 (+/- 4)	-	12 (+/- 4)	16 (+/- 1)
Nitrate	11.2	4.14	1.32	< 0.05
Arsenic	0.024	0.054	0.056	0.042
Copper	0.38	0.27	0.26	0.35
Lead	0.54	0.85	0.69	0.64
Silver	0.02	0.01	0.01	0.0016
Zinc	1.02	1.22	0.87	0.94
Pond 2 South[a]				
pH (s.u.)	9.83	9.57	10.1	9.8
TDS	486	384	396	350[b]
Total CN	0.10	0.145	0.042	0.18
Free CN	0.03	< 0.1	0.04	< 0.1
Radium 226 (pCi/L)	0.0 (+/- 0.7)	-	0.5 (+/- 1)	0.4 (+/- 0.2)
Nitrate	5.82	1.78	0.16	< 0.05
Arsenic	<0.001	0.011	0.006	0.008
Copper	0.22	0.18	0.11	0.030
Lead	0.08	0.119	0.022	< 0.005
Silver	0.01	< 0.01	< 0.01	< 0.0006
Zinc	0.35	0.18	0.19	0.023

(continued)

Table 4-3. Concentrations of Selected Parameters in Tailings Collection Ponds (continued)

Parameter	10/30/87	9/10/88	9/15/89	8/23/90
Pond 2 North[a]				
pH (s.u.)	9.00	9.45	9.57	8.1
TDS	828	552	644	520[b]
Total CN	0.27	1.08	0.436	0.44
Free CN	0.13	0.4	0.29	0.2
Radium 226 (pCi/L)	0.0 (+/- 0.7)	-	1.0 (+/- 1.2)	4.0 (+/- 0.4)
Nitrate	14.4	9.83	12.5	3.4
Arsenic	0.015	0.019	0.005	0.0005
Copper	0.43	0.69	0.39	0.049
Lead	0.07	0.22	0.17	0.10
Silver	0.03	0.05	0.02	0.0003
Zinc	0.28	0.38	0.37	0.022

NOTES:

a These ponds receive run-off and precipitation-induced drainage from tailings areas 1 (ponds 4A, 4B, and 1 South) and 2 (ponds 2 South and North). No tailings have been placed in either area since early 1986. Area2 has been under reclamation since 1988. Ponds 4A and 4B now receive pregnant solution from the Ironclad heap leach pad.

b Believed by Nerco to be in error due to particulate passing through filter.

Source: Table G-1 in Nerco 10/19/90 (1990 Annual Report to MLRD).

presents sampling data. It should be noted that no additional tailings were added to the tailings piles after the end of 1985 or early 1986. Thus, samples do not reflect drainage from fresh tailings but rather precipitation infiltration and run-off from "old" tailings. Table 4-4 presents the results of samples of solutions taken when the vat leaching operation was active; in addition, the table presents results from single samples of fresh (within a few days of vat leaching) and aged (over 18 months after disposal) tailings solids that were taken in 1984. The fresh tailings were also subjected to an Extraction Procedure (EP) Toxicity test.

In mid-1985, the facility re-opened after a major expansion, during which four 2,000-ton vats (100 x 65 x 9 feet each) were added to the existing four 1,000-ton vats in the Victor Mill building (Nerco 2/12/86). Ore tonnages steadily increased (from and to unspecified levels) after July 1985 (Nerco 10/28/85). On November 6, 1985, the face of area 1, which was advancing northward with an acute-angled face (as the area between the Globe Hill heap and Range View Road, between which the tailings pile was advancing, narrowed), collapsed and sloughed into the collection pond. This led to an escape of about 125,000 gallons of cyanide solution. It also led to a number of proposed changes in tailings pile construction and configuration. These included reducing the design height from over 250 feet to 150 feet and constructing the pile in lifts with periodic benches. (Nerco 2/12/86 and 3/20-24/86; MLRD 1/2/86, 2/20/86, and 3/25/86) Although MLRD had requested in 1984 that final slopes be no greater than 3H:1V, a subsequent geotechnical study by Nerco's consultant led to MLRD approval of 2H:1V final slopes (Nerco 6/19/84, Dames & Moore 1984).

In January 1986, shortly after the tailings slough, the facility entered an extended period of inactivity. In 1990, Nerco applied to remove the temporary cessation notice. Plans were to conduct site preparation work within the approved tailings pile area and begin laying liner material to extend the pile. Although not explicitly described, Nerco presumably intended to re-activate the vat leaching operation and continue use of the (modified) tailings pile. (Nerco 9/17/90) However, the facility's vat leaching operation was not re-activated, since approval of the application to resume operations was not granted until October 29 (after the construction season) and Nerco in May 1991 submitted plans for a change from the vat leaching operation to a heap leach system. (MLRD 10/29/90, Nerco 5/10/91).

Tailings area 1 was permitted to cover over 11 acres--the actual area used was not determined. Apparently, this included the area of the Globe Hill heap that was to be covered with tailings beginning in 1985. (Silver State Mining Corporation 3/25/81; MLRD 7/1/85) The total volume or weight of tailings that were generated by the facility and that are currently located on the site was not determined.Original reclamation plans (in 1981) called for the tailings piles to be rough-graded and left with a "mining area flavor," with revegetation left to nature. The disturbed area around the tailings piles was to be revegetated. (Silver State Mining Corporation 3/25/81) Subsequently, MLRD added the requirement that the tailings piles be reclaimed at closure by regrading and revegetation. The operator at the time, Silver State Mining Corporation, was to establish a number of test plots to aid in reclamation planning. (Silver State 5/26/83). Once they assumed the permit in 1984, Nerco's proposed reclamation was similar. Nerco began reclamation of area 2 in 1985, when the entire area was graded to a slope of 2H:1V and fenced (Nerco 10/28/85). In 1988, Nerco established test plots for the revegetation of area 2 (Nerco 9/88). Through 1990, at least some aspens and other trees had survived, and Nerco had identified at least 15 forb and five grass species that had established themselves by "natural seeding" (Nerco 9/88, 9/89, and 10/90). The south and east sides of tailings area 1 were graded to 2H:1V in 1985, and test plots were established on this pile using Soil Conservation Service (SCS) rootstock (Nerco 10/28/85). In subsequent years, the area 1 test plots were described in the 1986 annual report as "disappointing" (Nerco 1/6/87) and in the 1987 report (Nerco 10/13/87) as having "zero results." According to Nerco, the SCS concluded that the rootstock had been dead at the time of planting.

In 1991, in its application to add the Ironclad heap leach pad to the Victor Mine permit, Nerco indicated that the rest of tailings area 1 would be graded to a 2H:1V slope. Nerco was formulating plans to bench the pile at 20- to 25-foot elevations, load the benches with a growth medium, and establish vegetation on the benches. In addition, Nerco indicated that Ironclad pit expansion would require moving about 90,000 tons of tailings from area 1 to an unspecified location. (Nerco 5/10/91) The current reclamation status of tailings areas 1 and 2 was not determined.

4.3.5 Ironclad Heap Leach Pads and Ponds (Permit 81-134)

In 1991, Nerco began construction of what will become a single 1.5 million square foot heap leach pad served by three solution ponds. Construction is to occur in three phases, with subcells and pads completed in early phases placed in operation while construction continues on subsequent phases. Figure 4-5

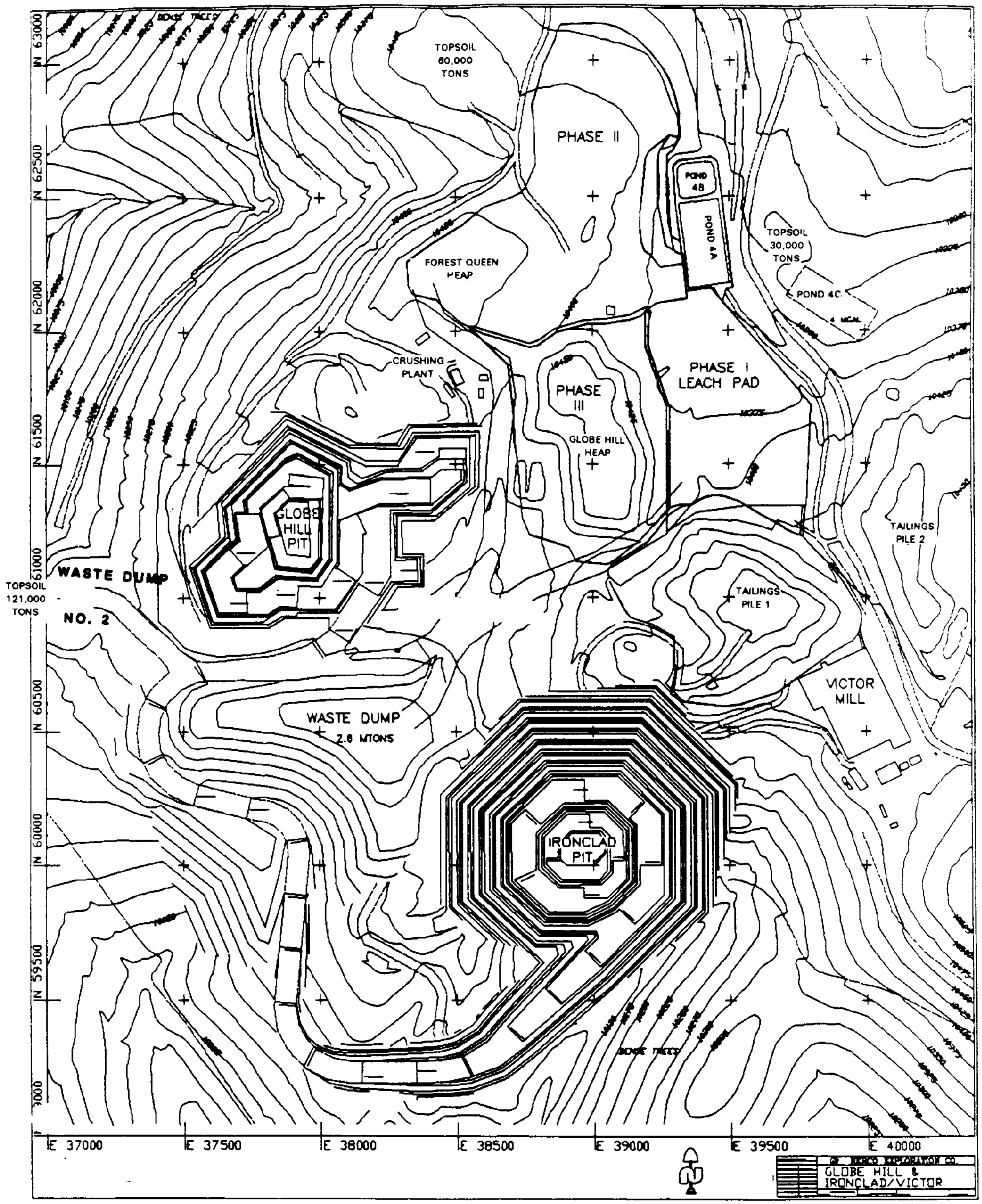


Figure 4-5. Location and Phases of Construction of the Ironclad Heap Leach Pad

(Source: Nerco 5/10/91, with additional labels added by EPA)

shows the location of the pad and the phases of construction. Part or all of two of the phases had been completed and were being actively leached by early 1992. The entire heap leach pad is known as the "Ironclad" pad. It should be noted that the descriptions of pad and pond construction in the following subsections are not based on "as-built" engineering reports but rather on permit applications and other MLRD and Nerco correspondence. Section 4.3.5.1 below describes the "Ironclad" pad, while solution ponds serving the heap leach pad are described in 4.3.5.2. Section 4.3.5.3 describes other wastes and materials managed by the facility.

Figure 4-6. Planned Final Configuration of Phase I Portion of Ironclad Pad

(Source: Nerco 5/10/91, with additional labels added) shows the planned final configuration of the Phase I pad and heap. The pad covers nearly 375,000 square feet and is surrounded by a three-foot berm. The pad, surrounding ditches, and the inner slope of the berm are all double-lined: the liner system consists of an 80-mil HDPE primary (upper) liner and a 60-mil HDPE secondary (lower) liner. A geonet layer, which connects with a series of wick drains that serve for leak detection, lies between the liners. The underlying surface consists of six or more inches of soils compacted to 90 to 95 percent (according to Nerco, the compaction should result in a permeability of less than 1×10^{-6} centimeters per second). The secondary liner lies on this prepared surface. Internal divider berms underlie the liner system and serve to divide the pad into 80,000 square foot subcells. These divider berms are three feet high with 1.5H:1V side slopes. The leak detection wick drains are installed between the liners along the upslope sides of the berms; the pregnant solution collection pipes (eight-inch slotted HDPE) are on top of the primary liner, again on the upslope sides of the berms. Figure 4-7

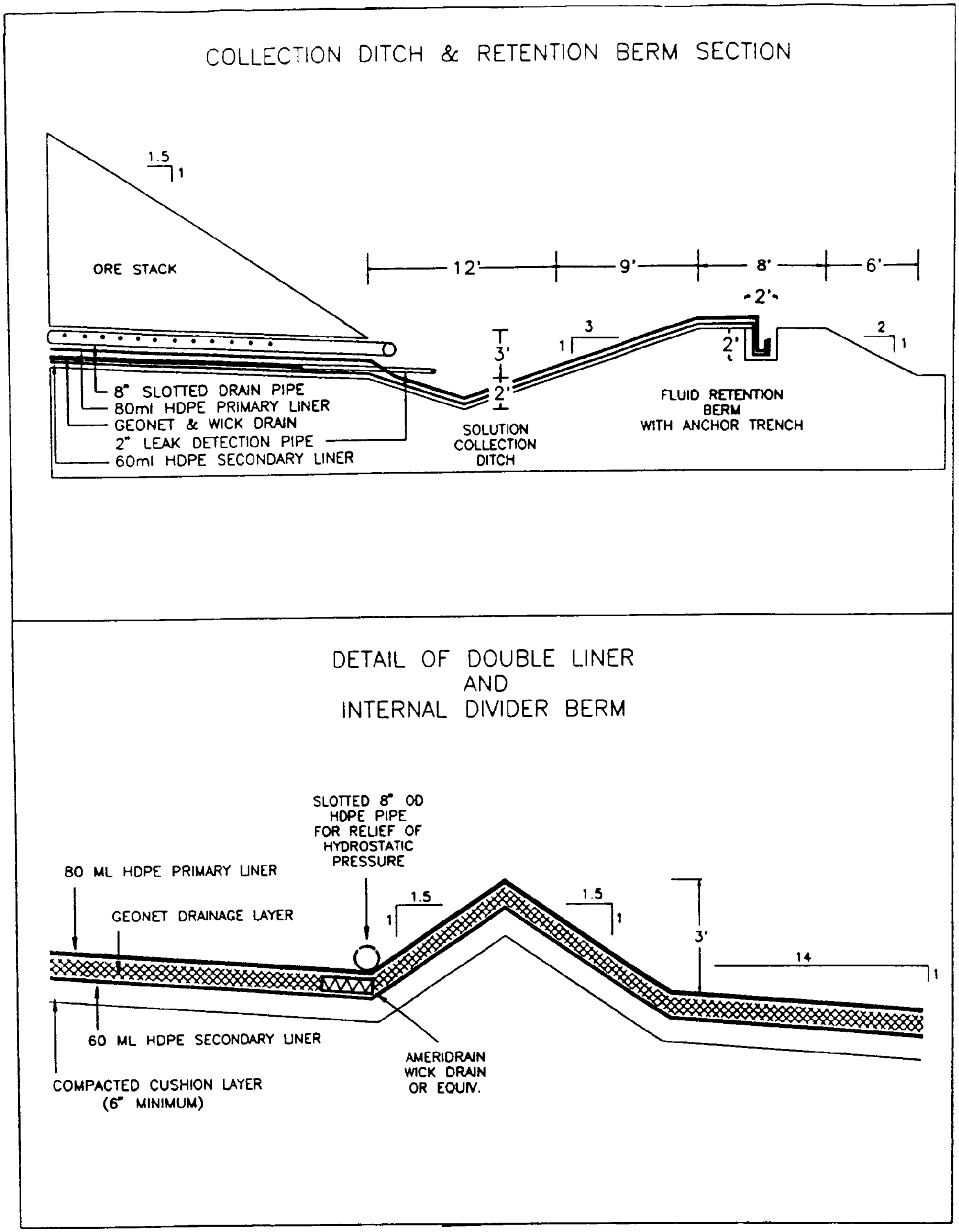


Figure 4-7. Ironclad Pad Liner and Internal Berm Construction

(Source: Nerco 5/10/91)

shows liner and internal divider berm construction. The Phase I pad is designed to hold about 800,000 tons of ore prior to becoming part of the larger Ironclad pad. (Nerco 5/10/91)

A solution collection ditch extends along the east side of the pad; the ditch is 12 feet wide and two feet deep and lined as described below. To the south, the liner was to be shingled under the existing 20-mil PVC liner that drains tailings area 1 (Nerco 5/10/91). The amendment (i.e., the application by which Nerco requested permission for the new construction and which was approved by MLRD) does not mention ditches on the west or north. The south and west are slightly uphill and the north side is to be joined to the full-sized pad during Phase III of construction. During the site visit, Nerco indicated that the shingling of the Phase I liner under the tailings liner was not successful, and that french drains were actually used to drain the tailings. Details on these drains (and how and where tailings drainage is conveyed), and on how the south end of the Phase I pad actually is constructed, were not determined. Although all sides were to be bermed, available documents do not mention collection ditches on any side but the east. (Nerco 5/10/91)

Ditch liners are part of the overall pad liner system described above. The pad liner extends across the ditch and up the inner slope of the three-foot outer berm, in which it is anchored in a two foot trench (a total of 12 feet across the ditch to the inner edge of the berm and four feet up to the anchor trench) (see Figure 4-7). The collection ditch receives fluids from the pregnant solution drain pipes and from two-inch pipes that drain the geonet and wick drains; the ditches convey the solution to Pond 4A. (Nerco 5/10/91)
According to the amendment, ore is stacked on the pad no closer than "15 to 20 feet from the edge of the liner" (whether this was to be measured from the inner edge of the ditch or from the anchor trench was not specified—in the latter case, ore would be stacked to the ditch's edge) (Nerco 5/10/91).

The approved amendment application in which Nerco described the Ironclad heap construction did not specify heap neutralization or reclamation requirements (Nerco 5/10/91).

Phase II Pad

Phase II of the construction, which was initiated and partially completed in 1991, will add an area of 669,557 square feet of lined pad when complete. This area is north of the present Globe Hill heap and immediately to the west of the pregnant solution pond (Pond 4A). The liner system, internal divider berms, and ditches were to be the same as for Phase I construction, with collection ditches along the north and east sides of the pad; the ditches drain to Pond 4A. The amendment did not mention whether berms would be constructed around the Phase II pad. (Nerco 5/10/91) The portion of this pad nearest the pregnant solution pond had been completed and was in operation by February 28, 1992, since a 30-foot lift sloughed into the collection ditch on February 29, as described in section 4.4.5.8 (MLRD 3/2/92). Overall, the Phase II portion of the pad is designed to hold about 1,300,000 tons of ore before it becomes part of the full-sized "Ironclad" pad. Figure 4-8

Figure 4-8. Planned Final Configuration of Phase II Portion of Ironclad Pad

(Source: Nerco 5/10/91, with additional labels added by EPA)

shows the planned final configuration of the Phase II pad.

The Forest Queen/2A heap leach pad (which is in the area covered by Permit 77-367) currently occupies western portions of the Phase II pad area. As noted above, it is constructed on the surface of the Globe Hill waste rock dump. The permit amendment authorizing the phased construction of the new Ironclad pad indicated that the Forest Queen/2A pad was to be "detoxified," then graded to the north and east (i.e., toward the pregnant pond area) (Nerco 5/10/91). The previous Globe Hill permittee (Dayspring Mining) reported to MLRD in 1988 that neutralization of the Forest Queen pad had been completed (Dayspring Mining Corporation 3/17/88). It is not clear if MLRD ever accepted this assurance. During the site visit, Nerco indicated that the heap would be rinsed with water, and possibly an oxidant, until cyanide levels were below 0.2 ppm; when this is accomplished, the "detoxified" spent ore will be placed on the waste rock dump. It was not determined if this detoxification had begun or had been completed (or would be necessary, as described in section 4.3.3.2), or when the Phase II construction would reach the area where the Forest Queen/2A pad is located.

Phase III Pad

Phase III of pad construction was planned to be completed in 1992. This phase requires lining the 463,488 square foot area between the Phase I and II pads. Part of the Phase III pad is to be located where the old Globe Hill heap leach pad is located. Liners and other construction are to be the same as described above for Phase I; liners for the Phase III area will be joined to the Phases I and II liners to make a single 1,500,000 square foot pad. The Phase III portion of the pad will hold 2,300,000 tons of ore. The Phase I and II heaps will join the Phase III heap and become a single heap that ultimately will contain about 4,400,000 tons of ore. Figure 4-9

Figure 4-9. Planned Final Configuration of Ironclad Heap Leach Pad

(Source: Nerco 5/10/91, with additional labels added by EPA)

shows the planned final configuration of the Ironclad heap when all phases of construction are complete.

Because the downhill portions of the Phase III pad (north and east) will be joined to earlier construction, collection ditches are not possible for the Phase III portion of the pad. According to the amendment, solution from the Phase III pad is to be collected by a "collection pipe" along the east edge of the Phase III pad where it joins the Phase I pad. Presumably (although this was not described) the same configuration will be used on the north side, where the Phase III and Phase II pads will join. The pipes in these areas will be on the liner underneath the heaps and will convey pregnant solution to Pond 4A. (Nerco, 5/10/91) The size of these pipes and the means by which they will be joined to the eight-inch pipes that drain the pad subcells were not described.

As with Phase II construction in the old Forest Queen pad area, Phase III will require the old Globe Hill heap to be "detoxified" and graded to the north and east (Nerco, 5/10/91). During the site visit, Nerco indicated that the old heap would be rinsed with water, and possibly an oxidant, until cyanide levels were below 0.2 ppm; when this is accomplished, the "detoxified" spent ore will be placed on the waste rock dump. It was not determined if rinsing would actually be necessary, or if it had been initiated or completed at the time of the site visit.

Leaching Operations

Ore is stacked on operating pads via a conveyor from the crusher. At any given time, a solution of 80 to 100 ppm sodium cyanide is applied (via drip irrigation) at 400 gallons per minute to one or more 80,000 square foot subcells (a rate of 0.005 gallons per minute per square foot). The length of time each cell will be leached was not determined.

Although not described in permit applications, ore is to be stacked on the heaps to over 100 feet (based on contour maps provided by Nerco). Ore is stacked in 20- to 30-foot lifts (during the site visit, Nerco indicated 20-foot lifts were used; during an inspection report, MLRD reported a 30-foot lift had failed (MLRD 3/2/92), so lift heights may be variable). Phase I and II pads will have separate heaps which will be joined as the Phase III heap rises between them.

As noted in chapter 4.2, mined ore has a moisture content of about four percent by weight. This is raised to six percent when a cyanide solution is applied to ore on the conveyor to the heap. Ore being actively leached has a moisture content of about 15 to 18 percent by weight. After active leaching is concluded, fully drained ore is expected to retain about 10 percent moisture by weight (Nerco 5/10/91).Solution from the Phase I and II areas of the pad (and possibly drainage collected in french drains downhill of tailings area 1) enters the appropriate collection ditch and is conveyed by gravity to the pregnant solution pond (Pond 4A). As described above, solution from the Phase III portion of the pad will be conveyed to the pond area via a pipe under the heap. (Nerco 5/10/91)

4.3.5.2 Solution Ponds

Three ponds provide primary containment for process fluids and precipitation. They have a combined capacity of 10,500,000 gallons. Each of the ponds is described separately below. Together, they are designed to contain (Nerco 5/10/91):

- Total run-off from their drainage areas of six days of 0.1 inch precipitation per day plus the 100-year/24-hour storm event, an additional 3.5 inches (a total of 4.1 inches of precipitation, or 5,375,200 gallons)

- Three days' pregnant solution discharges from actives areas of the heap(s) in the event of pump failure (1,728,00 gallons), and

- Normal working volumes of pregnant solution (2,000,000 gallons).

Pond 4A

Originally constructed in 1986, this pond was a Hypalon-lined run-off collection pond for tailings area 1 (Nerco 1/6/87). The pond was enlarged in 1991 to serve as the primary pregnant solution pond for the new Ironclad heap leach pad. The pond was enlarged to 150 feet wide, 302 feet long, and excavated in bedrock to a depth of 25 feet. The south end is sloped at 3H:1V and the other sides at 2H:1V. The pond's capacity is 5,000,000 gallons. The pond has two 60-mil synthetic liners over a compacted surface, with a geotextile leak detection system between the liners. There is a sump between the liners near the upper end of the pond, to which any fluids in the leak detection layer drain; fluids in the sump (and thus any leakage in the primary upper liner) are monitored from a leak detection manhole, connected to the sump by a four-inch pipe, on the north end of the pond. (Nerco 5/10/91)

The pond is surrounded by a three-foot-high berm that also is lined. Pregnant solution reaches the pond from lined collection ditches at the bases of the Phases I and II portions of the pad, and will come through pipes (see section 4.3.5.1 above) from the Phase III portion of the pad. (Nerco 5/10/91). The ditches (and presumably the pipes in the future) lead to a stilling basin immediately upgradient of the pond's north berm. This basin serves to slow the flow of pregnant solution before it enters the pregnant pond and also allows excess flow to be diverted to Pond 4C, the emergency overflow pond. The stilling basin is triple-lined; besides a double liner of 80-mil HDPE, a third layer of 80-mil HDPE is intended to enhance the pond's resistance to wear. Details on the basin's leak detection system, if any, were not available. From the stilling basin, solution formerly entered a six-inch PVC pipe, which passed through the Pond 4A liners (and was sealed to the basin's and pond's liners) into pond 4A; excess flow was directed through a similar pipe to Pond 4C. (MLRD 2/27/92 and 3/2/92) In early 1992, following a spill of pregnant solution, the means of conveying solution to Pond 4A was changed from the PVC pipe to a double-lined open trench after it was determined the transmittal pipe to Pond 4C had not been properly sealed to the basin's secondary liner (Nerco 3/6/92).

Pregnant solution is pumped from Pond 4A (and as necessary from the other ponds) at about 250 to 400 gallons per minute to the carbon-in-leach circuit(s) in the mill building.

Pond 4B

This pond was originally authorized by the approval for Technical Revision 4 and was constructed in 1986 (Nerco 3/10/86; MLRD 2/20/86 and 3/25/86). The pond is immediately below Pond 4A and originally served as a second tailings run-off collection pond. It now serves as an overflow pond for Pond 4A, the pregnant pond (Nerco 5/10/91). Pond 4B was excavated from bedrock in 1987. It was 160 feet long, 145 feet wide, and 25 feet deep, with a total capacity of 1,500,000 gallons. It was constructed with a geotextile underliner and 36-mil Hypalon liner. A 36-mil Hypalon-lined ditch conveys excess pregnant solution from Pond 4A to this pond. (Nerco 10/13/87) Pregnant solution from this pond is pumped back to Pond 4A when necessary.

Pond 4C

This pond was constructed in 1990 as an emergency overflow pond. The pond has a total capacity of 4,000,000 gallons. Like pond 4A, the pond is double-lined (two 60-mil HDPE liners) with a geotextile leak detection system between liners. The pond receives excess solution that cannot be accepted by the pregnant pond (Pond 4A). (MLRD 5/10/91) Pregnant solution from this pond is pumped to Pond 4A when needed.

4.3.5.3 Wastes and Other Materials Managed by Nerco

As noted above, gold recovery operations (from carbon-in-column circuits through doré production) take place in the Victor Mill building. This building contains the vats from the former vat leaching operation (see section 4.3.4) and has a concrete floor. The various tanks in the building (barren solution tanks, two operational series of portable carbon columns, caustic wash tanks, etc.) are surrounded by low concrete curbs for secondary containment. Some drains were observed during the site visit but it was not determined if they were individual sumps or if they drained to a central location.

All chemicals used on the site are stored in this building. These include unspecified amounts of sodium cyanide (in reusable flow-bins), Milsperse surfactants (in 20-50 pound plastic sacks), and acids and caustic (in unspecified containers). In addition, an unspecified amount of calcium hypochlorite is stored in the building for use in neutralizing any spills of cyanide solution that may occur. The more hazardous materials are stored in a fenced area within the building.

Maintenance on Nerco's seven haul trucks, three loaders, two drills, and other vehicles and equipment is conducted in a vehicle maintenance shop near the Victor mill building. Fuel oils and gasoline, hydraulic and lubricating oils, antifreeze, and other materials that are used on-site are stored in or near the mill and maintenance buildings; the amounts used and stored and the means of storage were not determined. Some used oil is used to fire two space heaters in the Victor Mill building; the remaining used oil is transported off-site by a contractor for recycling or disposal. The volumes of used oil burned and shipped off-site were not determined. A contractor provides Nerco with complete tire service: the contractor provides new tires, handles tire maintenance and repairs, and removes old tires; further information on tires was not available.

Nerco has an assay laboratory in the Carlton mill building. The capabilities of the laboratory were not determined. However, Nerco indicated that about 45,000 fire assays had been performed in the previous year for the Cripple Creek operations (these would have included assays of pit blastholes, tails solutions from carbon columns, samples from area waste rock dumps being considered as sources of ore, and exploratory drilling samples). Cupels from these assays are stored in 55-gallon drums but the number of drums and the total weight/volume of cupels were not known. Nerco indicated the cupels have high (but unspecified) levels of lead and that they were actively searching for a market, but had been unsuccessful to date. The laboratory also generates an unspecified amount of liquid, which are piped to the Carlton Mill pregnant ponds.

Nerco purchases five to seven million gallons of water from the town of Victor each year. The water comes from two reservoirs operated by the town and is purchased prior to the town's chlorination treatment (since the chlorine would interfere with leaching). Bottled water is used for potable water. According to Nerco, most of the water purchased from the town is used for drilling and for dust suppression in the mining area and on haul roads. No surfactants are added to the dust suppression water, although that was described as possibly being necessary in the future. Some unspecified quantity of the purchased water also is used as makeup water for barren solution, although most water used for that purpose comes from precipitation. Nerco moves water among its Cripple Creek operations as necessary. According to Nerco, any additional makeup water that may be necessary comes primarily from the Pad 4 ponds (see section 4.3.6.2), which in turn comes from snowmelt as well as excess water moved from the Pad 2 ponds (see section 4.3.6.1).

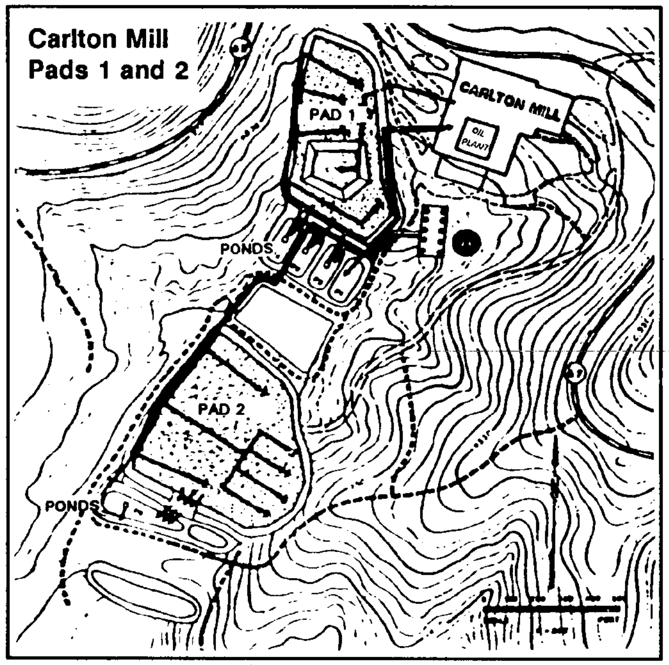
Nerco recycles paper, cardboard, and plastics from their Cripple Creek operations, and these materials are stored in a fenced "recycling" storage area at the Carlton Mill. Proceeds from the sale of such materials supports the local rescue squads.

Nerco also operates two small landfills, one on the Victor Mine and one on the Lillie permit (on what is known as the old Ajax mine property). The Department of Health delegates responsibility for regulating landfills and other waste disposal at mining operations to MLRD, but information on these landfills, and materials disposed in them, was not obtained. In addition, sanitary sewage from the Victor and Carlton Mill buildings is discharged to septic fields near the mills.

4.4 OTHER MAJOR CRIPPLE CREEK OPERATIONS

4.4.1 Carlton Mill (Pads 1 and 2)

The Carlton Mill was a conventional gold mill, using flotation for recovery. It operated from the early 1950s until about 1962. Tailings from the mill were disposed in a series of two or more dammed impoundments immediately below the mill in Arequa Gulch.



Provided by Nerco during site visit (relabeled)

In 1980, Texasgulf Minerals and Metals (actually, Cripple Creek and Victor Gold Mining Company (CC&V), which at that time was the joint venture of Texasgulf and Golden Cycle Gold Corporation) applied for and received MLRD permit number 80-244 to re-open the mill. Although Texasgulf operated the mill briefly, it was not active for long periods during the early 1980s. Beginning in 1985, Texasgulf began construction of what became heap leach Pads 1 and 2 and associated solution ponds. The sources of ore for both heaps were abandoned mine dumps in the Cripple Creek area. Some of these dumps were permitted under the Carlton Mill permit and some were permitted separately. The Carlton Mill permit area now exceeds 137 acres, including some outlying mine dumps. Appendix A presents a detailed history of the Carlton Mill permit. As with other Nerco permits, the Carlton Mill leach project has expanded incrementally since its inception, with successive approvals sought from MLRD for annual expansions.

Pad 1 is immediately uphill of the upper Carlton Mill tailings impoundment. Pad 1 was constructed beginning in 1985 and was actively leached through 1988 (and possibly after that time, although available documents were not clear). The pad is double-lined, but the liner materials were not described. The heap covers about 267,000 square feet and is divided into four cells by internal berms. A french drain system (otherwise undescribed) was installed below the lower liner in order to lower the water table. (CC&V 3/12/85) After the 1987 leaching season (active leaching occurred only in warmer months, six to eight months per year), the heap contained about 330,000 tons of ore, which had been placed in lifts 10 to 22 feet high. The total height was 40 to 50 feet. (CC&V 3/12/85, 11/20/87) During the site visit, Nerco indicated that Pad 1 now contains about 500,000 tons of spent ore and that they do not plan to add additional ore to the heap.

Four solution ponds are located immediately below Pad 1: a barren pond, intermediate pond, pregnant pond, and another pond for solution storage. All these ponds are double-lined (again, the liners were not described) and have a combined capacity of 3,000,000 gallons. Solution was sprayed onto an active cell of Pad 1 by sprinklers at rates of about 250 gallons per minute; solution was then collected in the intermediate pond. It was then applied to another cell and collected in the pregnant pond. Gold recovery was accomplished in a four-tank carbon-in-column series (apparently the same as described above for the current Ironclad/Globe Hill operations). Loaded carbon was removed to the Carlton Mill building, where gold was recovered with pressure caustic stripping, electrolytic plating onto stainless steel wool cathode, and smelting in a furnace to produce doré. Available information did not describe the gold recovery process further. Barren solution from the mill was then refortified with cyanide in the barren pond and re-applied to the heap. (CC&V 3/12/85, 11/20/87)

In early 1988, CC&V received approval to rehabilitate portions of the Carlton Mill and to install a carbon-in-leach gold recovery circuit so the facility could beneficiate high-grade ore in the mill. Tailings disposal was to occur on Pad 1: an unlined "pond" was to be excavated on the surface of the heap for tailings disposal. A total of 25,000 dry tons of tailings were to be disposed in this manner, in a slurry consisting of 45 percent solids. Geotechnical studies showed that the fine tailings (80 percent less than 325 mesh) would not migrate into the leached ore on the heap, but that water would; this water, after leaching through the heap, was to be collected in one of the solution ponds for recycle to the mill. (CC&V 11/20/87; MLRD 1/25/88) It is not known if the carbon-in-column circuit was ever completed or if tailings were actually disposed on the Pad 1 heap. During the site visit, Nerco indicated that Pad 1 contained about 500,000 tons of spent ore, but did not mention tailings.

Pad 2 was permitted in 1986. This heap leach pad is constructed immediately below Pad 1 on top of the upper Carlton Mill tailings impoundment. The tailings on which the pad was constructed ranged from seven feet deep near the upper end to 74 feet at the dam (which is known as Dam 1). The tailings are saturated below a depth of about 30 feet near the center and 45 feet near the dam. The pad was constructed by placing an 80-mil HDPE liner directly on the surface of the old tailings. Geotechnical studies showed that the tailings would support the heap, although the tailings (and thus the liner and heap) were predicted to settle about three feet near the center of the heap. (CC&V 1/16/86; Dames and Moore 1986; MLRD 3/24/86) In 1988, Pad 2 was expanded up an adjacent hillside to a total of 440,820 square feet (CC&V 2/23/87a, 2/22/88; MLRD 2/9/88, 2/26/88) It was not determined if Pad 2 was further expanded after 1988.

A fifth pond (Pond 5) was constructed immediately below Pad 2 but within the area of tailings (i.e., above the tailings dam) to serve as the pregnant pond for the pad. This double-lined (otherwise undescribed) pond was excavated into the tailings; it covers about 42,000 square feet and has a capacity of about 2,120,000 gallons. One of the four Pad 1 ponds serves as the barren pond for this heap. An additional 827,000 gallons of solution storage capacity is provided by the lined area between the Pad 2 heap and Pond 5. Another 2,400,000 gallons can be stored on the unlined tailings surface up to the crest of Dam 1. In 1987, an additional 3,500,000 gallons of capacity was obtained by improving the crest of the dam on the lower Carlton

Mill tailings impoundment (dam 2); this emergency storage area is unlined. (CC&V 1/16/86, 2/23/87a; Dames & Moore 1986; MLRD 3/23/87, 1/25/88) Total Pads 1 and 2 solution storage capacity exceeds 11,000,000 gallons, sufficient to contain normal working volumes, flow from the 100-year/24-hour storm event, and at least some heap drainage (CC&V 3/16/89).

During the site visit, Nerco indicated that Pad 2 contained about 2,000,000 tons of ore and that additional ore would be placed on the heap during the 1992 leaching season. Nerco also indicated that excess water from Pad 2 ponds (presumably during the idle winter season and spring snowmelt) may be transported to the Victory Project (see section 4.3.6.2 below) for storage. Whether Nerco uses run-off and drainage solutions collected in Pad 1 ponds as makeup water for Pad 2 or still recovers gold from it was not determined.

MLRD requires Nerco to monitor water quality in Arequa Gulch upstream and downstream of the tailings impoundments and heaps. Nerco also samples the french drain under Pad 1. Monitoring results from 1987 through 1989 are presented in Table 4-5. In addition, there are six "ground-water" monitoring wells; these wells are driven into the tailings near the base of Dam 1. The only analytical data other than pH and cyanide was for a sample from well PZ-6 on April 6, 1989; results are in Table 4-5.

Table 4-5. Monitoring Results from Pad 1 French Drain and from Arequa Gulch Upstream and Downstream of Pads 1 and 2

(milligrams per liter, unless otherwise indicated)

Parameter	Minimum and Maximum Concentrations 1987 - 1989			April 6, 1989
	French Drain below Ponds 1-4	Arequa Gulch Upstream	Arequa Gulch Downstream	Well PZ-6
Flow or Discharge	1 - 8 gpm	0 - 63 gpm	0 - 29 gpm	NA
pH (s.u.)	6.6 - 7.89	4.32 - 5.1[b]	7.69 - 8.1[b]	8.8[b]
TDS	850 - 860	1,100	1,400	6,200
Total CN	0.039 - 0.82[a]	< 0.005 - 0.065	0.008 - 0.14	NR
Free CN	0.019 - 0.82[a]	< 0.005 - 0.013	0.008 - 0.011	68
Nitrate (as N)	6.6	NR	NR	NR
Sulfate (as SO_4)	350 - 440	450 - 970	400 - 3,500	2,700
Cadmium[c]	< 0.005	0.015 - 0.021	< 0.005 - 0.007	0.079
Copper[c]	0.030 - 0.47	0.024 - 0.53	< 0.005 - 0.21	34
Lead[c]	< 0.005 - 0.0033	< 0.005 - 0.011	< 0.005 - 0.024	0.05
Silver[c]	< 0.0002 - 0.017	< 0.0002 - 0.0022	< 0.0002 - 0.0006	NR
Zinc[c]	0.028 - 0.38	1.8 - 2.7	0.009 - 1.1	10

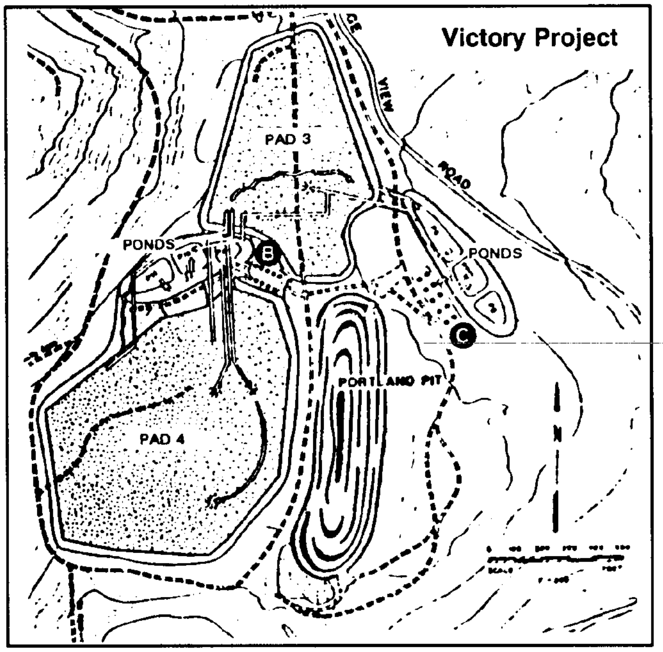
NOTES:

NR Not reported
a Does not include 11/2/88 results, which showed free CN at 9.0, total CN at 16.0.
b Except well PZ-6, reported data are field measurements. Maximum laboratory measurement upstream showed 6.0 s.u., minimum downstream was 7.0 s.u.
c Concentrations of metals are of total metals. In 1990, monitoring requirements were changed to dissolved metals.

Source: Pikes Peak Mining Company 4/27/90.

4.4.2 Victory Project (Pads 3 and 4)

Beginning in 1986, Texasgulf Minerals and Metals (through Cripple Creek and Victor Gold Mining Company (CC&V), which at that time was the joint venture of Texasgulf and Golden Cycle Gold Corporation), constructed and operated the major components of the Victory Project: two heap leach pads and an open pit. The permitted area covers 112 acres and is located on a ridge of Battle Mountain about 1.5 miles southwest of the Victor/Globe Hill area and about 0.5 miles north of the town of Victor. Much of the project area was covered by tailings and waste rock from historic operations, and these materials underlie some of the modern operations. With Nerco's purchase of Texasgulf in 1990 (Texasgulf was renamed Pikes Peak Mining Company), Nerco assumed responsibility for the permit (MLRD permit 86-024). Cripple Creek and Victor Gold Mining Company (CC&V) has managed the site since its inception. A detailed permit



Provided by Nerco during site visit (relabeled)

history of the Victory Project is presented in Appendix 4-B.

In 1986 and 1987, CC&V constructed Pad 3, a double-lined pad that covers about 280,000 square feet. Compacted tailings from an historic operation served as the lower liner, and an 80-mil HDPE secondary liner was placed over that. The base of the pad is sloped an average of about 10 degrees, with a 20 degree maximum slope in any one area. The source of ore for this pad was waste rock from area mine dumps. (CC&V 2/21/86) In 1986, a total of 416,000 tons were stacked on the heap, and an additional 430,000 tons were projected for 1987 (CC&V 2/23/87b, 5/26/87). During the site visit, Nerco indicated that Pad 3 contains a total of about 1,000,000 tons of ore.

Pad 4 was permitted in 1987 and construction was apparently completed in 1988. This 15-acre pad (660,000 square feet) was designed with a capacity of 1,825,000 tons of ore. It is immediately south of Pad 3. This heap was constructed on a prepared base of compacted tailings that were placed partially over waste rock (both historic dumps and 600,000 tons of rock from the adjacent Portland pit). This pad has a double synthetic liner (60-mil HDPE lower and 80-mil HDPE upper liners); a layer of granular tailings crossed by 3-inch HDPE pipes serves as a leak detection system. In 1988, about 672,000 tons of ore were placed on this heap in a single lift that averaged 20-25 feet deep (and ranged from eight to 30 feet, depending on site elevation). Ore came from the Portland Pit and from area waste rock dumps. (CC&V 7/17/87 and 12/8/87; Dames & Moore 3/16/89) The total amount of ore on Pad 4 was not determined.

In constructing Pad 4 and its associated ponds, a total of 12 old mine shafts were discovered; the top few feet of each was cleared out (by backhoe) and examined, then filled with gravel and compacted. (Dames & Moore 3/16/89) An unspecified number of shafts had also been filled and covered during construction of Pad 3 (CC&V 5/26/87, 2/21/86).

The Portland Pit, immediately downhill and to the east of Pad 4, was permitted in late 1987 and developed in 1988 and 1989. As planned, the pit's dimensions were to reach 1,400 feet long (north to south, oriented along the side of the ridge) by 500 feet wide (east to west) by 240 feet deep (near the center). A waste rock:ore ratio of about 2.5:1 was anticipated, reaching totals of 1,300,000 to 1,500,000 tons of waste rock and 500,000 tons of ore. The actual dimensions, and the amount of material mined, were not determined;

during 1988, about 600,000 tons of waste rock from the pit were used in preparing the base for Pad 4. (CC&V 8/12/87, Dames & Moore 3/16/89)

The Victory Project used a total of six solution ponds. A barren, pregnant, and emergency overflow pond serve Pad 3 and parts of Pad 4; the remainder of Pad 4 is served by three more ponds (again, a barren, pregnant, and emergency overflow pond). All of the six ponds are connected by buried and aboveground pipes that allow pumping or gravity flow between any of the ponds. All ponds (with the possible exception of the emergency overflow ponds) have two 60-mil HDPE liners and geotextile leak detection systems. In addition, lined berms surrounding the ponds provide additional storage capacity. Overall, the pond system is designed to contain flows from the 100-year/24-hour storm event, an additional 0.6 inches of precipitation, and one day's operating volume. (CC&V 2/21/86, 2/23/87b, 5/26/87, 7/17/87, and 12/8/87; Dames & Moore 3/16/89)

Details on barren solution makeup and characteristics were not determined. Barren solution was applied to each of the heaps via drip irrigation lines at a maximum rate of about 550 gallons per minute; leachate from the heaps then flowed by gravity through lined ditches to the respective pregnant ponds. Gold was recovered in portable carbon columns similar to those described in section 4.2.3. Carbon columns with loaded carbon were transported to the Carlton Mill for gold recovery. (CC&V 2/21/86, 7/17/87)

Reclamation requirements for the heaps include grading side slopes to an average of 2H:1V or less and detoxification, but not revegetation. The heaps are to be rinsed until effluent is of "acceptable quality" to MLRD. (CC&V 2/21/86, 7/17/87) Nerco indicated during the site visit that no cyanide solution was being applied to the heaps (the most recent time it was applied was not determined) but that the heaps were being sprayed for water balance purposes. Nerco indicated that the heaps would be decommissioned later in 1992. Reclamation for the solution ponds and other disturbed areas will involve seeding and revegetation. For the Portland Pit, there will be a warning/safety bench about 15 feet below the rim and an access ramp for wildlife and trespasser exit will be left. Available topsoil will be spread on benches and the pit floor, and grasses and trees will be established. Reclamation plans for the pit were approved late in 1989; the status of formal planning for other areas was not determined. (Texasgulf 5/10/89).

4.4.3 '76 (Bull Hill) Project

Sometime prior to September 1981, Newport Minerals began cyanide leaching operations at the '76 Project (also known as the Bull Hill Project), an area about 1.5 miles southwest of the Globe Hill site. This site, which Newport or other operators began operating in 1976, was a heap leach system that used waste rock from area waste rock dumps as ore. On August 27, 1981, the Mined Land Reclamation Board issued a Notice of Violation to Newport, citing the fact that MLRD had never received or approved an application for the "mining and reclamation operations" at the site. Newport was ordered to stop all leaching/mining operations at the '76 site and to submit a permit application or an application to amend the Globe Hill permit. Newport's attorneys responded that Newport questioned whether cyanide heap leaching in general was a "mining operation" and thus subject to permitting. In addition, Newport's attorneys questioned whether the

Table 4-6. Concentrations of Selected Parameters in '76 Project Barren and Pregnant Solution Ponds

(milligrams per liter, unless otherwise indicated)

Parameter	6/17/86[a]	9/14/88[b]
Barren Pond		
pH (s.u.)	NR	8.3
Total CN	NR	0.056
Free CN	NR	0.030
Silver	NR	< 0.005
Zinc	NR	< 0.005
Pregnant Pond		
pH (s.u.)	NR	9.1
Total CN	8.09	0.056
Free CN	2.11	0.29
Weak-acid-dissociable CN	2.79	NR
Silver	NR	0.030
Zinc	NR	0.006

NR Not reported

Sources:
a Newport Minerals 7/3/86
b Accu-Labs Research 10/7/88.

removal of waste rock from old dumps could be considered mining under the definition in Colorado's statutes (which referred to removal of ore from "natural occurrences"). MLRD's position was that both activities (i.e., heap leaching and waste rock removal) were considered mining. Notwithstanding Newport's retention of their arguments as possible defenses, the company submitted an application to amend the Globe Hill permit by adding the '76 site to the permitted area. The Mined Land Reclamation Board subsequently approved the amendment. (MLRD 9/2/81 and 12/21/81; Geddes et al. 9/15/81 and 11/25/81)

The heap, ponds, and plant covered an area of 14.2 acres. The 5.2 acre heap (225,400 square feet) had an "impervious soil pad" (no further description of the liner system was available). Barren solution with an "alkaline pH" and a sodium cyanide concentration of 0.05 percent was pumped from a barren pond and applied to the heap with a "pump and spray line system" (actual pH and application rates were not provided, nor was pond construction described). Pregnant solution drained (whether through drain pipes or directly on the soil pad was not described) to a "plastic lined launder" in the front of the pad, thence through "launder channels" to a Hypalon-lined pregnant pond. There also was an emergency overflow pond, but no details on construction were provided. Total capacity of all ponds was 807,840 gallons, sufficient to contain precipitation from the 100-year/24-hour storm event as well as at least 24 hours of heap drainage. Berms outside the ditch (i.e., outside the "launder") kept solution flow in the ditch. The heap was actively leached for six months a year; during winter, solutions were held in the ponds. Unspecified metallurgical difficulties in the "leaching plant" (otherwise undescribed) in late 1976 caused a cessation of operations until 1978. The amount of waste rock used as ore in 1976 was not determined; in 1978, about 12,000 tons were added to the heap and in 1981, another 100,000 tons were added. (Newport Minerals 9/14/81)

The quantity of ore added to the heap after 1981 was not described in available documentation. However, cyanide leaching apparently ended sometime in 1985 (Dayspring Mining Corporation 10/28/88).

Reclamation plans included rough-grading of the heap. The heap was to be rinsed with fresh water and, if cyanide were still detected, a "suitable oxidant" was to be added to the rinse. (Newport Minerals 9/14/81) When cyanide was no longer detected, the ponds were to be backfilled. The backfilled ponds and other disturbed areas were to be revegetated, but not the heap itself (MLRD 5/22/86).

Through the 1980s, the ponds were sampled at various times. Available monitoring data for the '76 site ponds are presented in Table 4-6. The current status of the '76 project was not determined during the site visit.

4.5 REGULATORY REQUIREMENTS AND COMPLIANCE

A number of State agencies are responsible for regulating various aspects of Nerco Minerals Company's Cripple Creek operations. These agencies and the permits they have issued to Nerco are described in sections 4.4.1 through 4.4.4 below.

4.5.1 Colorado Mined Land Reclamation Division

The agency with by far the most extensive involvement with the Ironclad/Globe Hill facility and Nerco's other Cripple Creek operations has been the Mined Land Reclamation Division (MLRD) in the Colorado Department of Natural Resources. MLRD is responsible for implementing the Mined Land Reclamation Act. MLRD reviews permit applications, inspects sites, and makes recommendations to the Mined Land Reclamation Board on permitting and enforcement actions. The Board issues rules and regulations under the Act; approves and issues permits, including bonding requirements; issues Notices of Violations and Cease and Desist Orders; and imposes civil and criminal penalties on operators that violate permits or Colorado statutes and rules.

Permits are issued under sections 110 and 112 of the Act. Regular Operations Permits, or "112 Permits" are required of operations that affect 10 or more acres or that extract more than 70,000 tons of material per year. Limited Impact Operations Permits, or "110 Permits," are required of facilities that will affect less acreage and extract less material than the 112 cutoffs.

A permit application is required prior to facility construction and operation. The application must describe the surrounding area and proposed construction in some detail, and must describe planned facility operations and reclamation. The right to conduct the mining operations must be demonstrated (e.g., through leases, proof of title, etc.), and mineral and surface owners of land in the proposed permit area and adjacent areas must be identified.

Following receipt of a permit application, MLRD notifies the Colorado Department of Health (agencies of which administer the water and air programs of the State), the Division of Water Resources in the Office of the State Engineer (which is responsible for water rights), and other State and local agencies. The various agencies may then provide comments and recommendations on the application. In the case of Teller County (and possibly other counties as well), the County and/or towns must find that the proposed operation is consistent with local requirements, including zoning. Applicants also place advertisements in local newspapers to inform the public that an application has been received and to indicate that records can be reviewed in MLRD offices. MLRD staff review the application and notify the applicant when additional information is necessary. Finally, MLRD inspects the site and recommends approval, conditional approval, or disapproval to the Board. The Board considers applications in open meetings. Upon approval, the Board issues the permit, which incorporates by reference the application, as well as any correspondence and technical reports that describe the permitted activities/facilities.

To add additional acreage to a permitted area, a permittee must apply for an Amendment to the permit. For changes that do not add additional areas (e.g., operational or other changes within the permit area), operators must apply for Technical Revisions to the permit. The review and approval process for Amendments and Technical Revisions is the same as described for original applications, except that Technical Revisions may not require public notice. There is no single "permit" that incorporates all the requirements applicable to an operator, as there is, for example, for NPDES permits (see section 4.4.2 below). Rather, the requirements are in approved applications for permits, Amendments, and Technical Revisions, in related MLRD and operator correspondence, and in technical studies and reports that are used to support applications.

When MLRD inspectors identify possible violations of permit conditions or Colorado regulations, they recommend specific remedies to the operator, who receives a copy of the inspection report. When potential violations are serious or are not remedied within time frames specified by the inspector, MLRD recommends appropriate actions to the Board. Such actions can include warnings, Notices of Violation, Cease and Desist Orders, permit revocation, and bond forfeiture. The Board also can impose civil penalties up to $1,000 per day per violation; actual penalties are based on a sliding scale based on seriousness and the operator's intent (e.g., inadvertent versus negligent versus willful); again, recommendations on penalties are made to the Board by MLRD.

MLRD typically inspects facilities at least annually, although more frequent inspections are conducted if conditions warrant. During the extended period when the Globe Hill and Victor Mine permits were not active (from 1986 through 1991), for example, MLRD conducted a number of inspections. MLRD also inspects facilities prior to Board consideration of applications or enforcement actions.

Table 4-6. Colorado Mined Land Reclamation Division Permits Issued to Nerco [a]

Permit Type	Permit Number[b]	Project Name	Project Description
112	M-77-367	Globe Hill	See text and Table 4-3. Globe Hill open pit mine, waste rock dump, three inactive heap leach pads, and portion of new Ironclad heap.
112	M-81-134	Victor Mine	See text and Table 4-2. Ironclad open pit mine, waste rock dump, most of new Ironclad heap, and gold recovery facility (through smelting). Formerly included vat leaching and tailings disposal.
112	M-80-244	Carlton Mill Project (Pads 1 and 2)	See section 3.6.1 and Appendix A. Previously, mill and carbon- in-leach facility, gold recovery facility (through smelting). Since mid-1980s, heap leach and CIC circuit, with old mine dumps serving as sources of ore. Pad 2 still operational.
112	M-86-024	Victory Project (Portland Pit, Pads 3 and 4)	See section 3.6.2 and Appendix B. Open pit, waste rock dump, two heap leach pads, and formerly portable carbon columns. Pit under reclamation, heaps to be "decommissioned" in 1992.
112	M-86-009	Lillie Project	Permitted as heap leach of many old waste dumps. Heap leach not constructed but dumps stripped for use as ore on Victory Project and Carlton Mill heaps (CC&V 3/31/86). • Originally, 241.33 acres permitted for following dumps: Joe Dandy, Last Dollar, Portland #2, Golden Cycle/Teresa, Lillie, Ajax, Upper Independence, Lower Independence, Portland #3, Victor, Deadwood, South Burns, Empire, Isabella, Wildhorse, and Morning Glory dumps. Total of 1,556,000 tons of rock. • Over the course of the permit, some areas were removed from this permit and placed under Gold Star and Victory permits.
112	M-88-064	Gold Star Pit	119.61 acres, open pit mine on Bull Hill to provide ore for Pad 4. • Permitted at 1,100 feet east-west x 900 north-south x unspecified depth. • In application, estimated 625,000 to 1,500,000 tons of ore, 2,400,000 to 3,000,000 tons of waste rock. Rock dump on nearby saddle, possibly to use some rock to replace other area dumps removed for leaching. • $32,600 bond proposed. • Inactive since August 1989 but drilling was to continue in 1992. (MLRD 10/26/88)
112	M-91-134	Cameron and School Section heap leach pads	Reclamation-only permit. Originally, these were Newport Minerals operations (permits 82-16 and 81-98). Following Newport's bankruptcy in 1985, MLRD revoked the bond and confiscated Newport's assets, including these heap leach pads. Under this permit, Nerco (CC&V) is to remove 600,000 - 700,000 tons of ore from heaps and transport to Ironclad heap for releaching. Not clear if Nerco or MLRD is responsible for final site reclamation (permit application indicates MLRD would be responsible, but undated "Reclamation Plan for Cameron and School Section Heap Leach Pads" indicates CC&V would reclaim the site.) (MLRD 3/4/92) A major spill occurred on the site in 1984, when 150,000 - 200,000 gallons of barren solution overflowed the ponds and reached Grassy Creek. A total of about 700,000 gallons of solution were stored in the vats in the Victor Mill building for several years during the Victor Mine's extended period of inactivity from 1986 through 1990.

Table 4-7. Colorado Mined Land Reclamation Division Permits Issued to Nerco (continued)

Permit Type	Permit Number[b]	Project Name	Project Description
Mine Dumps Permitted for Removal of Rock for Leaching			
110	M-82-214	Lower Mary McKinney Dump	7 acres: originally mined for decorative rock by Pioneer Sand Company, permit transferred to CC&V in 1986. (MLRD 4/18/83)
110	M-88-025	Anchoria Leland Dump	8.5 acres, 100,000 tons to Pads 2 and 4 beginning in 1988-1989 (MLRD 5/16/88a)
110	M-88-026	Chicago Tunnel	5.16 acres. Chicago Tunnel to be used to gain access to Proper Mine (underground) for mining of undetermined amount of ore, to be removed to Pad 2. (MLRD 5/16/88b)
110	M-88-096	Ocean Wave Mine Dump	9.8 acres, 40,000 tons to Pad 4 beginning in 1988-1989. (MLRD 11/28/88a)
110	M-88-097	Tornado/Raven Dump	7.3 acres, 50,000 to 70,000 tons to Pad 4 beginning in 1988-1989. (MLRD 11/28/88b)
110	M-88-098	Blue Flag Mine Dump	9.7 acres, 40,000 tons to Pad 4 beginning 1988-1989. (MLRD 11/28/88c)
110	M-88-099	Howard Mine Dump	9.9 acres, 55,000 tons to Pad 2 or 4 beginning in 1988-1989. (MLRD 11/28/88d)
110	M-88-100	Index Mine Dump	9.9 acres, 95,000 tons (< 70,000 tons per year) to Pad 2 beginning in 1988-1989. (MLRD 12/9/88)
110	M-89-059	Rigi Mine Dump	6.0 acres, 5,000 tons to Pad 4 beginning in 1989. (MLRD 7/14/89)
110	M-89-060	Upper Mary McKinney Mine Dump	8.9 acres: 60,000 tons to Pad 2 beginning in 1989-1990. Required studies, stabilization, and retention of existing cribbing supporting dump. Permit issued following NOV for mining without a permit (removal began after application but before issuance). (MLRD 7/27/89a)
110	M-89-061	Hull City and Sacramento Mine Dumps	9.9 acres, 18,000 tons to Pad 4 beginning in 1989. Permit issued following NOV for mining without a permit (removal began after application but before issuance). (MLRD 7/27/89b)
110	M-90-109	Bertha B and Maggie Dumps	5.0 acres, 27,000 tons to Pad 2 or 4 beginning in 1990-1991. (MLRD 10/2/90a)
110	M-90-110	Midget Mine Dump	5.0 acres, 57,000 tons to Pad 2 beginning in 1990-1991 (MLRD 10/2/90b)
110	M-90-111	Moon Anchor Dump	9.0 acres, 70,000 tons to Pad 2 beginning in 1990-1992. (MLRD 10/2/90c)
110	M-91-114	Clyde/Modoc Dump	10 acres, unspecified tonnage (< 70,000 tons per year) to Pad 2 in 1991-1992. (MLRD 11/7/91)

NOTES:

a Most permits are actually issued to Cripple Creek and Victor Gold Mining Company, although some are issued to Nerco or Pikes Peak Mining Company.

b The first number in the permit number reflects the year in which the original permit was issued.

shows MLRD permits issued to Nerco (and/or its subsidiaries and operating companies). As noted previously, the area affected by Nerco's Ironclad/Globe Hill project was formerly two separate permitted operations with two separate operators: the Globe Hill project under permit 77-367 and the Victor Mine under 81-134. The areas have now been consolidated by Nerco into a single project, with some facilities extending over both permit areas (e.g., the Ironclad heap leach pad) and some facilities used in common (e.g., the crusher, the waste rock dump, and the Victor Mill).

At the time of the site visit, the Victor site was held solely by Nerco, while the Globe Hill site was a joint venture between Nerco subsidiary Pikes Peak Mining Company and Golden Cycle Gold Corporation. According to Nerco, the Victor operation has since been added to the joint venture. Nerco's other Cripple Creek operations are generally permitted separately, as shown in Table 4-7. As can be seen, individual waste rock dumps that Nerco (or predecessor operators) proposed to remove and leach on the Victory or Carlton Mill pads are often permitted separately. MLRD and Nerco indicated that at least some of the 110 permits for waste rock dumps were in the process of being consolidated into a single permit.Reclamation of each of Nerco's Cripple Creek sites is guaranteed by a bond, which is in the form of a surety by St. Paul Fire and Marine Insurance Company in the favor of Nerco (or Pacificorp). The total surety is for $1,000,000, with stipulations for individual bonds for individual sites. Bonds are based on the operators' and MLRD's estimate to reclaim the site in accordance with the Mined Land Reclamation Act and local requirements. During the site visit, MLRD indicated that bonds established prior to 1991 would be re-examined and re-calculated in the near future. The total amount of bonding required of Nerco for its various operations was not determined. Reclamation bonds ranged from $1,000 for some of the areas where waste rock was removed for leaching to $391,948 for the Ironclad/Victor permit area.

For Nerco's Ironclad/Globe Hill project and the other Cripple Creek operations, MLRD operational and performance requirements are found throughout the many applications (for the original permits and for numerous Amendments and Technical Revisions) and the extensive correspondence for each permit area (i.e., permits 77-367 and 81-134 in the case of Ironclad/Globe Hill). Table 4-8 presents a permit history of MLRD permit 81-134, originally issued to Silver State Mining Corporation for the Victor Mine and assumed by Nerco in 1984. Table 4-9 presents a similar history of permit 77-367, originally issued to Newport Minerals in 1977 for the Globe Hill project and subsequently assumed by Dayspring Mining Corporation in 1986 and Nerco (actually, Pikes Peak Mining Company) in 1991. The tables show the dates when applications (for the permits, amendments, and technical revisions) were submitted or approved, identify the permittee at the time, and describe the permitted operations.

The tables are based on materials in MLRD permit files, as cited in the table. Similar tables for the Carlton Mill and Victory Projects are presented in Appendices A and B, respectively.

4.5.2 Colorado Department of Health, Water Quality Control Division

The Water Quality Control Division in the Colorado Department of Health is authorized to implement the National Pollutant Discharge Elimination System (NPDES) in Colorado by means of the Colorado Discharge

Permit System (CDPS). The State has not issued CDPS permits to Nerco's MLRD-permitted operations since they are designed not to discharge to surface waters (except storm water from some areas and some sites). However, the State has issued CDPS permit CO-0024562 to the Cripple Creek and Victor Gold Mining Company for discharges from the Carlton Tunnel to Fourmile Creek. The permit was reissued on March 12, 1992, and is effective from May 1, 1992 through March 31, 1997.

Mine water proved to be a problem throughout the history of the Cripple Creek mining district. The Carlton Tunnel was completed in 1941 and drains hundreds of miles of underground workings in the district. It extends six miles from the Cripple Creek area to Fourmile Creek, a tributary of the Arkansas River. In the mining district, the tunnel is at an elevation of about 7,000 feet above sea level, or 2,000 to 3,000 feet below the surface. At its discharge end, the elevation is about 6,700 feet.

Table 4-8. Permit History of the Victor Mine (MLRD Permit 81-134)

Permit 81-134: Victor Mine			
Date	**Event**	**Permittee**	**Description**
March 25, 1981 to September 8, 1981 (Silver State Mining Corporation 3/25/81; MLRD 9/8/81)	Permit application	Silver State Mining Corporation Lessor (surface and mineral): Gaston Coblentz and Cherry M. Lawrence	7.4 acre 5-year, mine, including: • 1.8 acre open pit (Ironclad mine), partly in previously mined pit. Final size to be 225 x 350 feet x 100-150 feet deep. 15-foot wide benches at 30 foot intervals (height). • Plastic lined 4.43 acre tailings area with 15-20 foot dam downslope to impound tailings water. • 0.15 acre crushing plant, 0.05 acres for field conveyors, 0.93 acres for processing plant (no further descriptions) • Reclamation: generally, leave as "mining area." Fence entire pit perimeter, grade tailings dump to 2H:1V or less, resoil/reseed impoundment dam and benches; grade and revegetate other areas. • Described in MLRD notes only (correspondence not obtained): closed vat cyanide system in 200 x 200 building. 9.5 inch concrete rebar construction, with rubber waterstops in joints. 4 vats, 3-day cycle; double-rinse tailings, conveyor to tailings. Ore drained for at least two hours before 4-6 hour unloading process. • No waste rock, No water diversion needed (no upslope area). • $7,000 bond proposed; actual amount required not determined.
December 1983 (Silver State 12/7/83)	Technical Revision 1	Silver State Mining Corporation	Add vehicle maintenance building, enlarge another building and parking lot, all on existing permit area.
March 1983 through June 1984 (Silver State 5/26/83, MLRD 5/30/84)	Amendment 1	Silver State Mining Corporation	Increase sizes of pit, waste rock dumps, and tailings. Added tailings area 2 across Range View Road. Also included tailings reclamation plan: establish test plots to allow development of final revegetation/reclamation plan. New permit area was 54.2 acres. Bond increased by $36,400 to $127,896.
June 1984 MLRD, (6/20/84)	Change in operator	Nerco Minerals Company	

Table 4-8. Permit History of the Victor Mine (MLRD Permit 81-134) (continued)

Permit 81-134: Victor Mine			
Date	**Event**	**Permittee**	**Description**
June 1984 to October 1984 (Nerco 6/19/84, MLRD 10/17/84, 3/21-22/85, and 1/2/86)	Amendment 2	Nerco Minerals Company	Expansion of facilities and operations: • Regrade and deactivate tailings area 2, extend tailings area 1 to north, with perimeter berms and 20-mil PVC liner. Reclamation plan for tailings: regrade to 2H:1V and revegetate. Establish test plots to assess revegetation options. • Build two new collection ponds in addition to four existing ponds. • Sample tailings collection ponds monthly for pH, free CN; sample annually for full suite of parameters. • Re-locate Range View Road to east. • Deactivate old and establish new waste rock dump. • Increase water usage five-fold to 100 gpm. • Increase mining rate to 3,000 tpd. • Increase bonding to $373,948. • Apparently added four 2,000 ton vats (Nerco 2/12/86 refers to this addition).
August 1984 (Nerco 8/22/84)	Technical Revision 2	Nerco Minerals Company	Replace 3.2 acres of undisturbed lands with 3.2 acres to be used for haul road from pit to dump. (Presumed approved; no correspondence obtained.)
March 1, 1985 (MLRD 3/1/85)	Technical Revision 3	Nerco Minerals Company	Exchange 11.2 undisturbed areas designated for waste dump with another 11.2 acres, where dump was actually proposed to be located.
1985 (MLRD 7/1/85)	Amendment	Nerco Minerals Company	7-acre tailings area on adjacent Globe Hill project (the old Globe Hill heap) removed from Newport Minerals permit 77-367, to be added to permit 81-134. Nerco also was to assume responsibility for Globe Hill heap leach pregnant pond. (Documentation on actual addition of the area to permit 81-134 not obtained.)
January 24, 1986 (Nerco 1/24/86; MLRD 1/28/86)	Notice of Temporary Cessation	Nerco Minerals Company	Cease operations for at least 180 days. During hiatus: • Transfer solution in tailings disposal area to empty vats as necessary to maintain capacity for 100-year/24-hour storm event. . • Stabilize and seed topsoil stockpiles. • Divert run-on from undisturbed areas. • Continue monitoring integrity of facilities and monthly/annual sampling of collection ponds. Cessation lasted until 1990.

Table 4-8. Permit History of the Victor Mine (MLRD Permit 81-134) (continued)

Permit 81-134: Victor Mine			
Date	**Event**	**Permittee**	**Description**
March 25, 1986 (Nerco 2/12/86, 3/20&24/86; MLRD 1/2/86, 2/20/86, 3/25/86)	Technical Revision 4	Nerco Minerals Company	Site in cessation status. Revisions to tailings disposal system in response to November 6, 1985, tailings slough. Some were previously approved in Amendment 2: • Change pile foundation preparation, reduce planned height to 150 feet. • Avoid steep slopes as tailings liner advances • Relocate county road 84 to allow room for 500-foot-wide front for tailings advance. • Reduce working face slope to 2:1. • Relocate tailings collection ponds to permanent location: one to be constructed immediately, one on resumption of production. • Convey drainage/run-off from pile to pond in 18-inch pipe laid in Hypalon-lined ditch.
February 26, 1987 (MLRD 2/26/87; Nerco 1/6/87)	Technical Revision 5	Nerco Minerals Company	Site in cessation status. Change in method of transfer of run-off/seepage from tailings area to collection pond. Formerly, 18-inch plastic pipe in 20-mil PVC-lined ditch. Pipe failed due to faulty resin. Changed to: from tailings ditches directly into open double-lined bermed ditch (36-mil Hypalon liner over geotextile over existing 20-mil PVC liner); drain into 18-inch pipe enclosed in underliner to pass through berm around pond. Inside berm, discharge end of pipe to rest on top of lined portion of pond.
October 17, 1990 (Nerco 9/17/90; MLRD 10/29/90)	Reactivation of Victor Mine	Nerco Minerals Company	End cessation that began in late 1985. Planned work included expansion of tailings pile to north (as planned in TR 4): • Site preparation within approved tailings pile area • Laying upgraded liner material (described only as "upgrade from the approved PVC liner")
May 10, 1991 (Nerco 5/10/91)	Amendment 1	Nerco Minerals Company	Three-phased construction in 1991 and 1992: • New 1,500,000 square foot double-lined "Ironclad" heap leach pad, partially built where Globe Hill (Phase III) and Forest Queen (Phase II) heap leach pads were located. See section 3.5 for construction details. • Globe Hill and Forest Queen pads to be "detoxified" (not described further). • Move 90,000 tons of existing tailings pile for pit expansion (relocation site not specified). • Existing tailings pile to be graded to 2H:1V with 20- to 25-foot benches. Formulate plans to load benches with growth medium and establish vegetation. • At closure, construct six-foot fence around Ironclad pit. • Reclamation of new pad not described. • Add 12 or 20 acres to permit (application cited both figures) for a total of 217.1 acres. • Total reclamation costs and bonding: $391,948 ($18,000 from additions, $373,948 already existing).

Table 4-9. Permit History of the Globe Hill Project (MLRD Permit 77-367)

Permit 77-367: Globe Hill Project			
Date	**Event**	**Permittee**	**Description**
September 30, 1977 (Gold Resources Joint Venture 1977)	Permit application	Gold Resources Joint Venture: Caithness Corporation, managing partner. Surface owner and lessor: Stratton Cripple Creek Mining & Development Company	26.9 acre open pit mine and heap leach (entire lease area was 630 acres): • 6.5 acre main pit and 0.67 east pit (12.63 acres total disturbed area) • 4 acre heap leach pad (350 x 500 feet) • 8 acre waste rock dump (600 x 580 feet) • 0.28 acre pond site (120 x 100 feet) • 2.2 acres of roads. • Seasonal mine (April through November) of oxidized telluride gold ore. • Zero discharge facility, no NPDES permit. • $12,500 reclamation bond • Previously, site had been mined since 1892, most recently in summers of 1972-1976.
June 5, 1978 (Gold Resources Joint Venture 1978; MLRD 4/12/79)	Amendment 1	Gold Resources Joint Venture	Added 11.34 acres to permit to cover planned 1978 operations: 1.14 acres to open pit; 3.7 acres to pad site, 1.44 acres to pond site, 5.06 acres to waste rock dump. Total permitted area: 39 acres. Additional bond not specified.
March 29, 1979 (Newport Minerals, Inc. 3/29/79)	Change in operator	Newport Minerals succeeded Gold Resources Joint Venture (Newport's parent company was Gold Resources, Inc.).	
September 2, 1981 (MLRD 8/2/81 and 12/21/81; Geddes, MacDougall, Geddes & Paxton 9/15/81 and 11/25/81)	Notices of Violation and Cease and Desist Order	Newport Minerals, Inc.	• NOV for constructing/operating heap leach system (Forest Queen pad) within permitted area although not described in approved plans. Also constructed pad and pond (pad 2A) in permit area. Required to submit technical revision to incorporate operations and facilities into approved plan. • A second NOV for operating cyanide leaching operation on Bull Hill (the '76 site). Ordered to cease leaching/mining operations and to submit permit application or amendment. Newport, through its attorneys, took the position that heap leaching was not "mining" and thus did not require a permit but nevertheless submitted the technical revision and amendment (see below and text).

Table 4-9. Permit History of the Globe Hill Project (MLRD Permit 77-367) (continued)

Permit 77-367: Globe Hill Project			
Date	**Event**	**Permittee**	**Description**
September 1981 (Geddes, MacDougall, Geddes & Paxton 11/25/81; MLRD 12/21/81)	Technical Revision (1?) (associated with Amendment 2)	Newport Minerals, Inc.	[Application not obtained; technical revision described in references cited.] Existing Forest Queen and 2A pads added to permitted operations within permit area (previously cited for operating heaps without describing in approved application). Pads are located on surface of waste rock dump (MLRD 7/1/85).
September 14, 1981 (Newport Minerals 9/14/81)	Amendment 2	Newport Minerals, Inc.	Added '76 site, about 14.2 acres, to existing permit. About 1 to 1.5 miles SW of original permit area, on ridge between two dry gulches. • 225,400 square foot (5.2 acres) heap leach pad and ponds; originally constructed in 1976, with waste rock from area dumps used as ore. Experienced metallurgical difficulties in "plant" in late 1976, shut down until 1978. In 1978, 12,000 tons added to top of heap; another 100,000 tons added in 1981. Orpha May, Logan, Blue Bird, Dexter, Specimen, and American Eagle dumps served as ore. Heap constructed in 20 foot lifts. Pond capacity 807,840 gallons (> 100-year/24-hour storm event). • Used 0.05 percent NaCN solution. "Prepared pad" of "impervious design" (no other description). "Plastic lined" "launder channels" convey solution to plastic lined collection ponds. Seasonal operation, with solutions held in ponds over winter. • Also an emergency catch basin downhill of ponds for overflow. Relined by Newport. • '76 site to be fenced. (Site had been mine dumps prior to 1976). Newport "relined" the pond and fenced the area; they also agreed, when leaching was complete, to measure effluents until quality approximated nearby streams. The amendment brought the total permitted acreage to 53.2 acres. Additional bonding (if any) was not determined.
March 26, 1982 (MLRD 3/26/82)	Amendment 3	Newport Minerals, Inc.	Incorporated 6.8 acres (for new total of 60 acres) of five old mine dumps on west of Globe Hill into permit. Dumps to be used as source of ore for one or more heap leach pads. Dumps included: Colorado King, Proper, Geneva, Chicago and Cripple Creek Tunnel, Abe Lincoln. Increased bonding by $8,500 (total not determined).

Table 4-9. Permit History of the Globe Hill Project (MLRD Permit 77-367) (continued)

Permit 77-367: Globe Hill Project			
Date	**Event**	**Permittee**	**Description**
September 1982 (MLRD 9/27/82)	Technical revision (2?)	Newport Minerals, Inc.	Added 0.68 acre of new heap to SE corner of existing '76 pad and enlarged pond. No change in acreage or bond. (Described in MLRD 7/1/85)
May 1984 MLRD (5/30/84 and 7/1/85)	Amendment 4	Newport Minerals, Inc.	Added to permit: 7 or 8 acre storage area for tailings from contiguous Silver State Mining Company (permit 81-134) vat leach operation ("short term solution to Silver State's waste disposal problems"). • 6.4 acre area to be lined with 20-mil PVC, sealed with Silver State liner at boundary (on south). About 662,000 tons of tailings, 100 feet high at highest point. 1,500 tpd for six months (June - November 1984), 3,000 tpd through June 1985, when full capacity reached. Surrounded on N, E, and W by 12-foot buffer ditch and 8-foot berm. • Solution collection pond (210 x 100 x 4 feet, 1.65 acre-feet) at NE corner, with drainage ditch from surrounding berm. 4-inch pipes in tailings to drain to pond. To contain 100-year/24-hour storm event. Leachate/run-off to be pumped to Victor mill. • 12,500 cubic yards of topsoil stored on W corner (on liner). • Final contours: Benches at 30-foot intervals, 2H:1V slope. • Including access roads, total acreage after amendment: 68.12 acres (or 67, according to Amendment 5). • Additional financial warranty: $17,500. • This entire area removed from this permit in 1985 and added to Nerco permit 81-134. See amendment 5 below.
September 28, 1984 (MLRD 9/28/84)	Technical Revision 4	Newport Minerals, Inc.	On-site disposal of triple-rinsed and crushed "disused" cyanide containers in area of waste rock dump. To be covered with 12 inches soil/clay, then rock. Change followed inspection orders.

Table 4-9. Permit History of the Globe Hill Project (MLRD Permit 77-367) (continued)

Permit 77-367: Globe Hill Project			
Date	**Event**	**Permittee**	**Description**
July 1, 1985 (MLRD 7/1/85)	Amendment 5 (and additional permit conditions)	Newport Minerals, Inc.	• Deepen and enlarge pit: increase approved area 4.5 acres to 8.5 acres, depth from 125 to 300 feet. Not known if implemented. • Add 13 acres to waste rock dump, for total of 27 acres. Not known if implemented. • Construct and operate new vat leach and tailings disposal operation similar to adjacent Nerco operation. Never implemented. • Change from nonreusable barrels for cyanide and caustic to reusable containers. Not known if implemented. • Remove the 7-acre storage area (including Globe Hill heap) for Permit 81-134 tailings authorized by amendment 4 (see above) from this permit and convey to Nerco. (Reilly 4/6/86, MLRD 5/22/86). • Financial warranty increased from $25,00 to $90,000. Never posted since most construction not implemented. • Over five year period, four waste dumps about 0.75 miles SSE of plant (the Logan, American Eagle, and Lucky Gus 1 and 2 dumps), to be removed and sold as decorative rock. At least partially accomplished.
May - September 1986 (MLRD 6/3/86, 7/1/86, 9/4/86, 9/29/86)	NOVs and Cease and Desist Order	Newport Minerals, Inc.	Globe Hill (Forest Queen) violations, described in text. Delay in corrective action led to $109,800 civil penalty. Culminated in Dayspring Mining Corporation succeeding Newport Minerals as operator.
September 25, 1986 (MLRD 9/25/86)	Change of operator	Dayspring Mining Corporation	
September - November 1988 (MLRD 9/13/88, 9/22/88a, 11/15/88, 1/23/91)	NOV M-88-013 and Cease and Desist Order	Dayspring Mining Corporation	'76 site violations, described in text. Led to civil penalty of $2,600. Finally resolved in 1991 upon succession of Cripple Creek and Victor Gold Mining Company as operator, with Pikes Peak Mining Company as manager.
February 6, 1991 (MLRD 2/6/91)	Change in operator	Pikes Peak Mining Company	Included $25,000 bond (by St. Paul Fire & Marine Insurance Co. of Minnesota, coverage from 11/13/90 through 11/13/93.

Table 4-9. Permit History of the Globe Hill Project (MLRD Permit 77-367) (continued)

Permit 77-367: Globe Hill Project			
Date	**Event**	**Permittee**	**Description**
October 10, 1991 (Nerco 5/10/91, MLRD 10/10/91)	Technical Revision 4 (and unnumbered revision to Permit 81-134) [This was the second revision #4.]	Pikes Peak Mining Company	Detoxify and grade Forest Queen pad to northeast. Where heap pad is located, install part of new Ironclad pad and collection ditches. Solution to drain to pregnant pond 4A on adjacent Victor Mine permit. Part of phased construction under permit 81-134, described in sections 4.2.2 and 4.3.5. Ultimately, this pad to be joined to other components of Ironclad heap leach pad.
Summary	Reclamation requirements for entire site (MLRD 5/22/86): • Pit: rough-grade, leave warning bench and access/exit ramp, fence area, no revegetation. • '76 and Forest Queen/2A heap: rough-grade, rinse until no detectable cyanide, no revegetation. • Ponds: Monitor for one year or more: when fluids are similar to Cripple Creek or Wilson Creek, backfill ponds and revegetate. • Waste rock dump: rough-graded, with dome-like upper surface (to eliminate ponding/infiltration); maximum slope 1.5H:1V, no revegetation. • Other areas: grade to slopes less than 3H:1V, mulch and revegetate. Remove buildings and equipment.		

Table 4-10. Discharge Limitations and Monitoring Data for Carlton Tunnel

(units are milligrams per liter except as noted)

Effluent Parameter	Effluent Limits Effective May 1992[a]		Effluent Limits 1986 - 1992[b]		Concentrations Reported January - December 1991[c]
	30-Day Average	Daily Maximum	30-Day Average	Daily Maximum	Minimum - Maximum
Flow (MGD)	2.58	N/A	2.57	N/A	1.87 - 2.40
pH (s.u.)	6.5 - 9.0		6.5 - 9.0		7.8 - 8.1
Total Suspended Solids	30	N/A	30	45	< 5.0 - 14
Silver	0.0008	0.0212	0.0001	0.0002	< 0.0001 - < 0.0002
Zinc	0.130	1.00	0.14	0.28	0.006 - 0.13
Lead	0.03	0.920	0.08	0.16	< 0.005
Copper	0.059	0.098	0.04	0.08	< 0.005
Cadmium	N/A		0.007	0.014	< 0.005
Mercury	N/A		0.0001	0.0002	< 0.0001
Acute WET[d],[e]	N/A	50 %/ IWC=37%	N/A		N/A
Chronic WET[e]	Report		N/A		N/A

NOTES:
- N/A Not applicable
- a These effluent limits are effective May 1992. Limits of silver, zinc, lead, and copper are on "potentially dissolved" metals. Twice-monthly sampling is required for all parameters except WET, which is tested quarterly (for acute) or semi-annually (for chronic).
- b These effluent limits were effective prior to May 1992 (and were applicable during the period covered by the monitoring data presented in the table). Limits and monitoring results are on "potentially recoverable" metals except mercury, which is on "total" mercury. All parameters were required to be sampled monthly.
- c Although there are limits on 30-day average and maximum daily concentrations, monthly averages generally were based on single samples, whose results were reported both as averages and daily maxima. Thus, the ranges presented are simply the maximum and minimum concentrations reported during the year.
- d WET: Whole Effluent Toxicity limits added in 1992 revision. Acute 48-hour tests are to use Ceriodaphnia sp. and acute 96-hour tests are to use fathead minnows. Chronic tests also are to use these species the first year, after which CC&V may petition for one-species testing.
- e Through March 31, 1995, there are reporting requirements only. Acute toxicity limits will begin April 1, 1995. Limits: no acute toxicity in effluent from discharge point. Limit will be considered exceeded if species mortality in any dilution (including 100 percent effluent) exceeds 50 percent; or if there is a statistically significant difference in mortality (at 95 percent confidence level) between control and any dilution less than or equal to an Instream Waste Concentration (IWC) of 37 percent.

Sources: Colorado Department of Health, Water Quality Control Division CDPS permit CO-0024562 (3/12/92) for limits effective May 1992; Monthly Discharge Monitoring Reports for 1991, submitted to Colorado Water Quality Control Division, for prior limits and 1991 monitoring data.

Flow from the Carlton Tunnel can be discharged directly to Fourmile Creek (discharge point 001) or can be routed through a series of four settling ponds prior to discharge (discharge point 002). The CDPS permit places the same effluent limits on both discharge points. The CDPS permit includes limits on flow and on conventional and toxic pollutants; it also requires whole effluent toxicity testing. Effluent limits from the previous and the new permits are show in Table 4-10. Also presented in Table 4-10 are the results of 1991 effluent monitoring. In 1991, discharges to Fourmile Creek averaged over 2,000,000 gallons per day, and all discharges during the year were from the settling ponds.

The new permit limits are conditional on no mining occurring in the Carlton Tunnel; if there is mining activity in the tunnel or at a level underground that requires active pumping of water out of the Carlton Tunnel, alternate limits (not presented in Table 4-10 since no underground mining is occurring or planned) would apply. The permit requires that acute whole effluent toxicity (WET) be monitored quarterly, chronic WET semiannually, and other parameters twice monthly.

4.5.3 Colorado State Engineer, Division of Water Resources

The Division of Water Resources (DWR) in the Office of the State Engineer is responsible for water rights issues in the State. MLRD routinely informs DWR of pending permit applications and amendments. On July 30, 1991, after reviewing Nerco's application to amend permit 81-134 (to add the Ironclad heap leach pad, including solution ponds), DWR recommended against approval of the amendment. According to DWR, Nerco "cannot legally store or use precipitation run-off [in the solution ponds described in section 4.3.5] without a Water Court decree, or a substitute water supply plan approved by this office [i.e., DWR] unless all decreed water rights in the Arkansas River basin downstream of this location are fully satisfied." DWR records showed no existing decreed water rights and no substitute water supply plan, so DWR recommended against approval of the amendment. (Colorado Office of the State Engineer, 7/30/91) Notwithstanding this recommendation, MLRD approved the amendment after being assured by Nerco that the company would immediately apply for a substitute water supply plan. According to Nerco during the site visit, this process is still underway. It is not clear why the State Engineer took exception to this particular amendment and these particular ponds: previous ponds on this site and other sites have long been used to collect run-off, and there is no indication that DWR had taken exception to any previous permitting action, for this or any other of Nerco's operations.

4.5.4 Other Permits

A number of other permits have been issued for various Nerco operations (permits may have been issued to Cripple Creek and Victor Gold Mining Company, Pikes Peak Mining Company, or Nerco--this was not determined). These are shown in Table 4-11. As noted in chapter 4.2, a contractor operates the crusher and conveyor system at the Ironclad/Globe Hill site and is permitted separately. EPA did not obtain and examine the permits listed in Table 4-11 or those issued to Nerco contractors.

Table 4-11. Other Permits Issued to Nerco Minerals for Cripple Creek Operations

Permit number	Type permit	Operations covered
Colorado Department of Health		
83TE351	Air emissions	Not determined.
88TE241	Fugitive air emissions	Clyde/Modoc mine dump crushing and rock removal
87TE301F	Fugitive air emissions	Portland Pit: operations covered not determined
C-13, 269-1-5, C-7	Not determined	Ajax (Lillie project?) Carlton Mill
Colorado Division of Mines		
Not determined	Magazine permit	Not determined

Source: Provided by Nerco during site visit.

4.6 ANNOTATED LIST OF REFERENCES

Accu-Labs Research, Inc. 1988 (October 7). Letter from M. Fabisiak, Water Laboratory Supervisor, to B. Mountford, Dayspring Mining Corporation. Sample results from sampling of '76 Project Ponds.

Cripple Creek and Victor Gold Mining Company. 1985 (March 12). Amendment to Mined Land Reclamation Permit 80-244. Application for permit amendment (Carlton Mill project: add heap leach Pad 1 and ponds.)

Cripple Creek and Victor Gold Mining Company. 1986 (January 16). Amendment No. 2 to Mined Land Reclamation Permit 80-244. Application for permit amendment 2 (Carlton Mill project: add lower heap leach pad (Pad 2) and ponds on top of old tailings impoundment.)

Cripple Creek and Victor Gold Mining Company. 1986 (February 21). Victory Project: Application for Regular 112 Permit. Approved as permit 86-024 on April 29, 1986. (Includes associated reports and correspondence.)

Cripple Creek and Victor Gold Mining Company. 1987 (February 23). Victory Project, Permit 86-024: Application for Technical Revision 2: expand pad 3 to design size to accommodate 1987 operations. (Presumed approved with TR 2, no correspondence obtained.)

Cripple Creek and Victor Gold Mining Company. 1987a (February 23). Carlton Project, Permit 80-244: Application for Technical Revision 1: increase height or expand area of Pad 2, add additional water storage capacity for 1987 operations. (Includes July 14 letter clarifying pad options and Dames & Moore letters on proposed actions.)

Cripple Creek and Victor Gold Mining Company. 1987b (February 23). Victory Project, Permit 86-024: Application for Technical Revision 3: actually a revision to TR 2 (2/23/87). Includes June 2, 1987, approval letter from MLRD.

Cripple Creek and Victor Gold Mining Company. 1987 (April 27). Letter from C.A. Tapp, Resident Manager, to A. Baldridge, Colorado Mined Land Reclamation Division. Carlton Mill Pads, Permit 80-244: Description of April 20 spill of cyanide solution.

Cripple Creek and Victor Gold Mining Company. 1987 (July 17). Victory Project, Permit 86-024: Application for Amendment 1: Construct additional heap leach pad (Pad 4) and ponds. Includes October 28, 1987, approval letter from MLRD.

Cripple Creek and Victor Gold Mining Company. 1987 (August 12). Victory Project, Permit 86-024: Application for Amendment 2: Add Portland Pit open pit mine to permitted operations. (Presumed approved, no correspondence obtained).

Cripple Creek and Victor Gold Mining Company. 1987 (November 3). Letter from C.A. Tapp, Manager, to A. Baldridge, Colorado Mined Land Reclamation Division. Carlton Project, Permit 80-244: Description of October 8 spill of barren leach solution.

Cripple Creek and Victor Gold Mining Company. 1987 (November 19). Letter from C.A. Tapp, Manager, to A. Baldridge, Colorado Mined Land Reclamation Division. Carlton Project, Permit 80-244: Description of repairs to primary liner of Pad 1 following detection of fluids in leak detection system.

Cripple Creek and Victor Gold Mining Company. 1987 (November 20). Letter from C. Gerity, Manager of Mining, to A. Baldridge, Colorado Mined Land Reclamation Division. Carlton Project, Permit 80-244: Application for Technical Revision 2 (Rehabilitation of Carlton Mill for carbon-in-leach recovery of gold from high-grade ore and placement of tailings on heap leach Pad 1). Includes Dames & Moore letter of November 5, 1985 detailing geotechnical engineering study results.

Cripple Creek and Victor Gold Mining Company. 1987 (December 8). Victory Project, Permit 86-024: Application for Amendment 3: Revised plans for Pad 4 approved in Amendment 1. (Presumed approved, no correspondence obtained.)

Cripple Creek and Victor Gold Mining Company. 1987 (December 18). Letter from C.A. Tapp, Manager, to A. Baldrige, Colorado Mined Land Reclamation Division. Victory Project, Permit 86-024: Documented conversations and provided history of leak in primary liner of Pad 3 (solution in leak detection pipe).

Cripple Creek and Victor Gold Mining Company. 1988 (February 22). Letter from C. Gerity, to J.T. Doerfer, Colorado Mined Land Reclamation Division. Carlton Mill Project, Permit 80-244, Amendment 3: Response to MLRD adequacy letter of 2/9/88 on Amendment 3 application. Includes Dames & Moore letter dated 2/22/88 that provided responses to some items.

Cripple Creek and Victor Gold Mining Company. 1988 (May 31). Victory Project, Permit 86-024: Application for Technical Revision 4: Construct haulage road across Pad 3. (Includes July 7, 1988, MLRD approval letter.)

Cripple Creek and Victor Gold Mining Company. 1988a (May 31). Carlton Mill Project, Permit 80-244: Application for Technical Revision 3. Change in construction of leak detection system in expansion of Pad 2 approved in Amendment 3. Includes Dames & Moore letter of 5/19/88 describing actual construction.

Cripple Creek and Victor Gold Mining Company. 1988 (July 21). Letter from C.A. Tapp, Manager, to J. Doerffer, Colorado Mined Land Reclamation Division. Victory Project, Permit 86-024: Notice of errant blast in Portland Pit.

Cripple Creek and Victor Gold Mining Company. 1988 (August 22). Letter from A. Tapp, Manager of Mining and Development, to J. Doerffer, Colorado Mined Land Reclamation Division. Victory Project, Permit 86-024: Description of August 12 cyanide spill.

Cripple Creek and Victor Gold Mining Company. 1988 (September 20). Letter from C. Gerity, to C.M. Farrell, Colorado Mined Land Reclamation Division. Victory Project, Permit 86-024: Transmittal of soil sampling results from August 12 cyanide spill.

Cripple Creek and Victor Gold Mining Company. 1990 (February 12). Letter from E.T. Hunter, Project Manager, to J. Doerfer, Colorado Mined Land Reclamation Division. Victory Project, Permit 86-024: Notice of January 9 spill of cyanide solution on Pad 4.

Cripple Creek and Victor Gold Mining Company. 1990 (November 5). Letter from J.P. Rovedo, Safety/Environmental Engineer, to J. Doerfer, Colorado Mined Land Reclamation Division. Victory Project, Permit 86-024: Notice of November 5 spill of cyanide solution on Pad 4.

Cripple Creek and Victor Gold Mining Company. 1991 (January 23). Letter from J.P. Rovedo, Safety/Environmental Engineer, to J. Doerfer, Colorado Mined Land Reclamation Division. Permit M-77-367: Proposed responses to NOV M-88-013 upon succession of CC&V as operator of Globe Hill and '76 Project.

Cripple Creek and Victor Gold Mining Company. 1992 (March 6). Letter from E.T. Hunter to C. Mount, Colorado Mined Land Reclamation Division. Permit M-81-134: Submission of internal company memoranda describing February 26 pregnant solution spill incident and February 29 ore slide and pregnant solution spill.

Dames & Moore. 1984 (December 12). *Report, Geotechnical Engineering Studies, Stability of Mine Waste Dumps and Tailings Disposal Piles, Victor Mine, Cripple Creek, Colorado, for Nerco Minerals Co*. Prepared for Nerco Minerals Company (Job No. 12077-005-14). Submitted to Colorado Mined Land Reclamation Division on December 26, 1984.

Dames & Moore. 1985. *Report, Subsurface Exploration and Preliminary Design, Proposed Lower Carlton Heap Leach, Carlton Mill, Near Victor Colorado, for Cripple Creek and Victor Gold Mining*

Company. Prepared for CC&V. Submitted to Colorado Mined Land Reclamation Division with application for Permit 80-244, Amendment 2, on January 16, 1986.

Dames & Moore. 1989 (March 16). *Report; As-Built Construction; Heap Leach Pad No. 4 Near Victor, Colorado; for Cripple Creek and Victor Gold Mining Company*. Prepared for Texasgulf Minerals and Metals, Inc. (Job No. 09077-033-19). Submitted to Colorado Mined Land Reclamation Division on March 30, 1989.

Dayspring Mining Corporation. 1988 (October 28). Letter from B. Mountford, President, to F. Banta, Colorado Mined Land Reclamation Division. (Response to MLRD letter of September 22 and September 21 Notice of Violation M-88-013 and Cease and Desist Order.)

Geddes, MacDougall, Geddes & Paxton (attorneys for Newport Minerals). 1981 (September 15). Letter from M.E. MacDougall to P.H. Evans, Colorado Mined Land Reclamation Division. Permit 77-367: Response to MLRD letter of September 2 letter transmitting two NOVs and a Cease and Desist Order.

Geddes, MacDougall, Geddes & Paxton (attorneys for Newport Minerals). 1981 (November 25). Letter from M.E. MacDougall to P.H. Evans, Colorado Mined Land Reclamation Division. Permit 77-367: Request for 9/21/81 technical revision to be incorporated into Amendment 2 and agreement to reline the '76 Project pond, fence the area, and monitor effluents at closure.

Gold Resources Joint Venture. 1977 (September 30). Application for Mining and Reclamation Permit, Regular (112) Permit Application Form. Submitted to Colorado Mined Land Reclamation Board. Application for Globe Hill project. Subsequently approved as Permit M-77-367.

Gold Resources Joint Venture. 1978 (June 5). Application for Amendment 1, Permit 77-367; Regular (112) Permit Application Form. Submitted to Colorado Mined Land Reclamation Board. Application to add 11.34 acres to Globe Hill project.

Lewis, A. 1982 (October). "Producing Gold for $160/Tr Oz in Victor, Colorado." *Engineering and Mining Journal*: pp. 102-105.

Nerco Minerals Company. 1984 (June 19). Letter from M.L. Clark, Vice President for Operations, to D.C. Shelton, Director, Colorado Division of Mined Land Reclamation. Permit 81-134: June 22, 1984, application for Amendment 2 following succession of Nerco as operator. (Grade and deactivate tailings area 2, extend area 1 and build collection ponds, new waste rock disposal area, add Globe Hill heap to this permit). Includes Nerco and MLRD correspondence, including revisions to application dated 9/20/84 and 9/21/84. Approved by MLRD 10/17/84.

Nerco Minerals Company. 1984 (August 22). Letter from J.R. Woodward, Senior Permitting Engineer, to B. Janes, Reclamation Specialist, Colorado Division of Mined Land Reclamation. Permit 81-134: Request for Technical Revision 2--replace 3.2 undisturbed acres for 3.2 acres for use as on-site haul road.

Nerco Minerals Company. 1985 (April 25). Letter from T.J. Schamberger, Chief Engineer, to P.C. Saletta, Colorado Division of Mined Land Reclamation. Permit 81-134: Response to MLRD inspection report on March 20-21 inspection of Victor Mine (MLRD 3/20-21/85).

Nerco Minerals Company. 1985 (May 9). Letter from T.J. Schamberger, Chief Engineer, to P.C. Saletta, Inspector, Colorado Division of Mined Land Reclamation. Victor Mine Permit 81-134: Letter advising of as-built modification to tailings liner construction.

Nerco Minerals Company. 1985 (October 28). Annual Report to Colorado Mined Land Reclamation Division for the year 1985. Permit 81-134.

Nerco Minerals Company. 1986 (January 2). Letter from T.J. Schamberger, Engineering Superintendent, to D.C. Shelton, Director, Colorado Division of Mined Land Reclamation. Permit 81-134: Certification of compliance with Cease and Desist Order dated December 20. (Tailings deposition on Victor Mine tailings pile west of Rangeview Road had been stopped.)

Nerco Minerals Company. 1986 (January 24). Letter from T.J. Schamberger, Engineering Superintendent, to D.C. Shelton, Director, Colorado Division of Mined Land Reclamation. Permit 81-134: Notice of temporary cessation of production at Victor Mine.

Nerco Minerals Company. 1986 (February 12). Letter from T.J. Schamberger, Engineering Superintendent, to C. Farrell, Colorado Mined Land Reclamation Division. Permit M-81-134: Application for Technical Revision 4. (Revised tailings disposal system after tailings slough on November 6, 1985.)

Nerco Minerals Company. 1986 (March 10 and March 14). Letters from E. Hunter, Senior Project Engineer, to C. Farrell, Colorado Mined Land Reclamation Division. Permit M-81-134, Technical Revision 4: Responses to Colorado Mined Land Reclamation Division letter of February 20 requesting clarification of items in Technical Revision 4.

Nerco Minerals Company. 1987 (January). Annual Report to Colorado Mined Land Reclamation Division for the year 1986, October 1, 1985 - September 30, 1986. Permit 81-134.

Nerco Minerals Company. 1987 (January 6). Letter from E. Hunter, Senior Project Engineer, to C. Farrell, Colorado Mined Land Reclamation Division. Permit 81-134: Application for Technical Revision 5. (Modification of method of transfer of run-off from tailings area to collection pond: remove failed 18-inch pipe and use lined open ditch.)

Nerco Minerals Company. 1987 (January 29). Letter from E. Hunter, Senior Project Engineer, to C. Farrell, Colorado Mined Land Reclamation Division. Permit 81-134, Technical Revision 5: Response to Colorado Mined Land Reclamation Division letter of January 12 requesting clarification of specific items prior to Board consideration of application for Technical Revision 5.

Nerco Minerals Company. 1987 (October 13). Annual Report to Colorado Mined Land Reclamation Division for the year 1987, October 1, 1986 - September 30, 1987. Permit 81-134. Includes addendum submitted January 1988.

Nerco Minerals Company. 1988 (September). Annual Report to Colorado Mined Land Reclamation Division for the year 1988, October 1, 1987 - September 30, 1988. Permit 81-134. Includes addendum submitted November 3.

Nerco Mineral Company. 1989 (March 30). Letter from E. Hunter, Senior Project Engineer, to C. Farrell, Colorado Mined Land Reclamation Division. Permit 81-134: Sampling results from Globe Hill heap run-off pond.

Nerco Minerals Company. 1989 (September). Annual Report to Colorado Mined Land Reclamation Division for the year 1989, October 1, 1988 - September 30, 1989. Permit 81-134. Includes addendum submitted November 17, 1989.

Nerco, Inc. 1990 (August 22). Letter from J.F. Resch, Jr., Director of Insurance and Risk Management, to D. Heyer, Colorado Mined Land Reclamation Division. Notice of Nerco purchase of Texasgulf Minerals and Metals from ELF Aquitane, Inc. Cited were MLRD permits 80-244, 82-214, 86-009, 86-024, 88-025, 88-064, 88-099, 88-097, 88-097, 88-100, and 88-098.

Nerco Minerals Company. 1990 (September 11). Letter from J.P. Rovedo, Safety/Environmental Engineer, to J. Doerfer, Colorado Mined Land Reclamation Division. Letter informed MLRD of pilot test using two truck loads of waste rock as aggregate for asphalt or other uses.

Nerco Minerals Company. 1990 (September 17). Letter from J.P. Rovedo, Safety/Environmental Engineer, to D. Hernandez, Colorado Mined Land Reclamation Division. Permit 81-134: Request for removal of temporary cessation notice (approved by Mined Land Reclamation Board on October 17). Re-activation of Victor Mine.

Nerco Minerals Company. 1990 (October 2). Letter from J.P. Rovedo, Safety/Environmental Engineer, to D. Hernandez, Colorado Mined Land Reclamation Division. Permit 81-134: Response to August 14, 1990 inspection report. Also includes October 8 letter.

Nerco Minerals Company. 1990 (October 24). Letter from J.P. Rovedo, Safety/Environmental Engineer, to D. Hernandez, Colorado Mined Land Reclamation Division. Permit 81-134: Response to August 14, 1990 inspection report.

Nerco Minerals Company. 1990 (October). Annual Report to Colorado Mined Land Reclamation Division for the year 1990, October 1, 1989 - September 30, 1990. Permit M-81-134.

Nerco Minerals Company. 1991 (May 10). Letter from J.P. Rovedo, Safety/Environmental Engineer, to D. Hernandez, Colorado Mined Land Reclamation Division. Permit M-81-134: Application for Amendment to Regular Operation Reclamation Permit, Victor Mine. (Add new Ironclad pad, enlarge pond 4A, add new storage pond 4C).

Newport Minerals, Inc. 1979 (March 29). Request to Succeed Operator at an Uncompleted Operation. Submitted to Colorado Mined Land Reclamation Board. Permit 77-367: Newport Minerals to succeed Gold Resources Joint Venture as operator of Globe Hill project.

Newport Minerals, Inc. 1981 (September 14). Application for Amendment 2, Permit 77-367; Regular (112) Permit Application Form. Submitted to Colorado Mined Land Reclamation Board. Application to add 14.2 acre '76 site to Globe Hill permit.

Newport Minerals, Inc. 1985 (June 24). Letter from V.F. Reilly to P.C. Saletta, Colorado Mined Land Reclamation Division. Results of 4/9/85 sampling of Globe Hill and other ponds.

Newport Minerals, Inc. 1985 (September 24). Letter from V.F. Reilly to P.C. Saletta, Colorado Mined Land Reclamation Division. Results of 7/19/85 sampling of Globe Hill and other ponds.

Newport Minerals, Inc. 1986 (July 3). Letter from V.F. Reilly to C. Farrell, Colorado Mined Land Reclamation Division. Results of 6/17/86 sampling of '76 Project ponds (Permit 77-367).

Newport Minerals, Inc. 1986 (July 18). Letter from V.F. Reilly to C. Farrell, Colorado Mined Land Reclamation Division. Results of June 1986 sampling of Forest Queen/2A ponds. (Permit 77-367).

Pontius, J.A. and R.A. Butts. 1991. "Geology and Gold Mineralization of the Cresson Deposit, Cripple Creek, Colorado." Presented at the 97th Annual Northwest Mining Association convention, Spokane, Washington, December 4-6, 1991.

Pikes Peak Mining Company. 1990 (April 27). Letter from E. Hunter to L. Oehler, Colorado Mined Land Reclamation Board. Victory Project, Permit 86-024 and Carlton Mill Project, Permit 80-244: Application for Technical Revisions to modify monitoring requirements. (Includes MLRD and CC&V correspondence, culminating in MLRD letters advising of Board approval.)

Pontius, J.A. and R.A. Butts. 1991 (December). "Geology and Gold Mineralization of the Cresson Deposit, Cripple Creek, Colorado. Presented at the 97th Annual Northwest Mining Association Convention; Spokane, Washington; December 4-6, 1991.

Reilly, V.F. 1986 (April 6). Letter from V.F. Reilly, PNT Mining Inc., to E. Bischoff, Colorado Mined Land Reclamation. Permit 77-367: Inquiry as to reclamation requirements and "environmental obligations" of the Globe Hill permittee. (Includes synopsis of Globe Hill permit transactions and reclamation requirements.)

Silver State Mining Corporation. 1981 (March 25). Application for Permit for Regular Mining Operation (for Victor Project - Ironclad Pit). Subsequently approved (on September 8, 1981) as Permit 81-134.

Silver State Mining Corporation. 1983 (May 26). Application for Amendment 1 to Victor Mine Permit 81-134: Enlarge pit, add waste rock dump and new tailings disposal area to permit. Includes May 1983 and January 1984 revisions to application and September 1983 plan for reclamation of waste rock dumps and tailings areas. Approved May 1984 (MLRD 5/30/84).

Silver State Mining Corporation. 1983. Annual Report [for 1983]. Permit 81-134.

Silver State Mining Corporation. 1983 (December 7). Victor Mine, Permit 81-134: Application for Technical Revision 1. (Add vehicle maintenance building, enlarge buildings and parking lot. Includes MLRD approval letter dated January 11, 1984.

Silver State Mining Corporation. 1984 (April 13). Letter from W.R. Reid, President/CEO, notifying vendors of imminent joint venture between Silver State and Nerco Minerals Company, with Nerco becoming Victor Mine operator.

State of Colorado, Department of Health, Water Quality Control Division. 1985 (November 6). Notes of Gary Soldano (?) on telephone notification by Teller County Health Services of a cyanide spill at Victor Mine.

State of Colorado, Department of Health, Water Quality Control Division. 1992 (March 12). Authorization to Discharge Under the Colorado Discharge Permit System, Permit No. CO0024562. NPDES permit issued to Cripple Creek and Victor Gold Mining Company, authorizing discharge from Carlton Tunnel.

State of Colorado, Mined Land Reclamation Division. 1979 (April 12). Letter from J.L. Schmieding, Reclamation Specialist, to M.H. MacDougall, attorney for Newport Minerals, Inc. Transmittal letter for permit 77-367. (Including copy of permit and application).

State of Colorado, Mined Land Reclamation Division. 1981 (August 14). Letter from J.L. Schmieding, Reclamation Specialist, to Silver State Mining Corporation. Notice that Silver State was conducting an unpermitted gold operation and that Board would hold a hearing on August 26, 1981.

State of Colorado, Mined Land Reclamation Division. 1981 (September 2). Letter from P.H. Evans, Reclamation Specialist, to T. Downing, Newport Minerals, Inc. Transmittal letter for two NOVs and a Cease and Desist Order. (For cyanide operations at unpermitted '76 site and undescribed cyanide operations [Forest Queen and 2A pads] at permitted Globe Hill site.)

State of Colorado, Mined Land Reclamation Division. 1981 (September 8). Letter from M. Stanton, Reclamation Specialist, to B. Reid, Silver State Mining Company. Permit 81-134: Notice of Board approval of permit application dated March 25, 1981. Includes prior correspondence, NOV and Cease and Desist order concerning disturbance before permit issuance.

State of Colorado, Mined Land Reclamation Division. 1981 (December 21). Letter from P.H. Evans, Reclamation Specialist, to T. Downing, Newport Minerals, Inc. Permit 77-367: Notice of December 16 Board approval of Amendment 2 (add '76 site to permit) and technical revision (add Forest Queen and 2A leach pad to permitted operations).

State of Colorado, Mined Land Reclamation Division. 1982 (March 26). Letter from P.H. Evans, Reclamation Specialist, to T. Downing, Newport Minerals, Inc. Permit 77-367, Globe Hill Project: Approval for amendment 3 (adding waste dumps to permit area for use as ore). Includes application and related correspondence.

State of Colorado, Mined Land Reclamation Division. 1982 (April 18). Mining and Reclamation Permit M-82-214. Issued to Pioneer Sand Company for removal of rock from (lower) Mary McKinney Dump for use as decorative rock. Property and permit transferred to Cripple Creek and Victor Gold Mining Company in 1986. Includes application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1982 (September 27). Letter from M. Stanton, Reclamation Specialist, to T. Downing, Newport Minerals, Inc. Permit 77-367, Globe Hill Project: notice of Board approval for (unnumbered) Technical Revision (add 40,000 square feet to existing heap--to receive ore from old mine dumps). Includes application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1984 (May 30). Letter from C. Russell, Reclamation Specialist, to B. Hester, Newport Minerals Inc. Globe Hill Permit 77-367: Notice of Board approval of amendment 4 (storage area for tailings from Silver State Mining Company mill). Includes application for amendment and related correspondence.

State of Colorado, Mined Land Reclamation Division. 1984 (June 20). Letter from M.S. Loye, Reclamation Specialist, to E.T. Hunter, Silver State Mining Company. Permit 81-134: Notice of June 27-28 Board consideration of request for transfer of permit from Silver State Mining Company to Nerco Minerals Company (pending payment of fees).

State of Colorado, Mined Land Reclamation Division. 1984 (September 28). Letter from C. Russell, Reclamation Specialist, to B. Hester, Newport Minerals Inc. Permit 77-367: Notice of Board approval of Technical Revision 4 (disposal of rinsed "disused" cyanide containers in an area to be covered by waste rock). Includes application for revision and related correspondence.

State of Colorado, Mined Land Reclamation Division. 1984 (October 11). Permit 81-134: Notice of Inspection and Inspection Report on October 11 inspection of Victor Mine by P.C. Saletta.

State of Colorado, Mined Land Reclamation Division. 1984 (October 17). Permit 81-134: Notice of Board approval of Amendment 1 (Nerco 6/20/84). Increase in bond to $373,948.

State of Colorado, Mined Land Reclamation Division. 1985 (March 1). Letter from P.C Saletta, Hydrologist/Geological Engineer, to B. Jacobs, Nerco Minerals Company. Permit 81-134: Notice of Board approval of Technical Revision 3 to Victor Mine permit. (Relocation of waste dump: Exchange 11.2 undisturbed acres designated for waste dump for another 11.2 acres where dump will occur.) Includes application for Technical Revision.

State of Colorado, Mined Land Reclamation Division. 1985 (March 20-21 and June 5). Notices of Inspection and Inspection Reports on March 20-21 and June 5 inspections of Victor Mine (Permit 81-134) by D. Berry, C. Farrell, and P.C. Saletta (March 20-21) and P.C. Saletta (June 5).

State of Colorado, Mined Land Reclamation Division. 1985 (May 30). Letter from P.C. Saletta, Hydrologist/Geological Engineer, to C. Gerity, Texasgulf Minerals and Metals, Inc. Permit 80-244, Carlton Mill project: Notice of Board approval for amendment 1 (add heap leach pads and ponds).

State of Colorado, Mined Land Reclamation Division. 1985 (June 11). Notice of Inspection and Inspection Reports on June 11 inspection of Victor Mine by P.C. Saletta.

State of Colorado, Mined Land Reclamation Division. 1985 (July 1). Letter from P.C. Saletta, Hydrologist/Geological Engineer, to K. Ennis, Newport Minerals, Inc. Permit 77-367, Globe Hill Project: Notice of Board approval for amendment 5 (enlarge pit, construct and operate vat leach facilities). Includes application and related correspondence.

State of Colorado, Mined Land Reclamation Division. 1985a (November 6). Memorandum to file by M.S. Loye, Reclamation Specialist, on notification by Nerco Minerals of tailings failure and resulting spill of "seep water" and other telephone conversations during the day (with EPA and Colorado Department of Health). Permit 81-134.

State of Colorado, Mined Land Reclamation Division. 1985b (November 6). Notice of Inspection and Inspection Report on November 6 inspection of Victor Mine by A.C. Baldridge, P. Saletta, and C. Farrell. (Following notification of tailings pile failure on same date.)

State of Colorado, Mined Land Reclamation Board. 1985 (December 20). Notice of Violation M-85-081 and Cease and Desist Order, issued to Nerco Minerals Company. (Issued for inadvertent violations resulting from a November 6, 1985, tailings failure and resulting runoff-collection pond spill at Victor Mine (Permit 81-134) . Assessed but waived $100 civil penalty.) Includes MLRD and Nerco correspondence, logs, analytical results related to tailings pile failure and November and December Board meetings and hearings (and MLRD notes on meetings).

State of Colorado, Mined Land Reclamation Division. 1986 (January 2). Letter from C. Farrell, Reclamation Specialist, to E. Hunter, Nerco Minerals Company. Permit 81-134: Request for clarification of items in report on November 6, 1985, tailings failure submitted by Nerco in preparation for anticipated Technical Revision.

State of Colorado, Mined Land Reclamation Division. 1986 (January 28). Letter from C.M. Farrell, Reclamation Specialist, to T.J. Schamberger, Nerco Minerals Company. Permit 81-134: Notice that Nerco's January 26, 1986, Notice of Temporary Cessation satisfied the requirements of Colorado Minerals Rules and Regulations Number 1.62.

State of Colorado, Mined Land Reclamation Division. 1986 (January 29). Notice of Inspection and Inspection Report on January 29 inspection of Victor Mine (Permit 81-134) by A. Baldridge, K. Hellner, M. Loye, and E. Bischoff.

State of Colorado, Mined Land Reclamation Division. 1986 (February 20). Letter from C. Farrell, Reclamation Specialist, to T. Schamberger, Nerco Minerals Company. Permit 81-134, Technical Revision 4: Acknowledgement of receipt of Technical Revision 4 on February 14 and request for clarification of specific items prior to Board consideration.

State of Colorado, Mined Land Reclamation Division. 1986 (March 24). Letter from A.C. Baldridge, Reclamation Specialist, to C. Gerity, Cripple Creek and Victor Gold Co. Permit 80-244, Carlton Mill project: Notice of Board conditional approval for amendment 2 (add Pad 2 and ponds). Conditional upon liner verification, as-built submissions, test plots, ground-water monitoring, etc.

State of Colorado, Mined Land Reclamation Division. 1986 (March 25). Letter from C.M. Farrell, Reclamation Specialist, to E. Hunter, Nerco Minerals Company. Permit M-81-134, Technical Revision 4: Notice of Board approval of Nerco's February 14, 1986, application for Technical Revision 4 and incorporation of terms into permit. (On-site corrective action to tailings piles and ponds.)

State of Colorado, Mined Land Reclamation Division. 1986 (March 31). Letter from D.C. Shelton, Director, to Cripple Creek and Victor Mining. Permit M-86-009: Notice of March 20 approval of 112 permit application for Lillie Project. Includes original and other applications and correspondence.

State of Colorado, Mined Land Reclamation Division. 1986 (May 22). Letter from C.M. Farrell, Reclamation Specialist, to V.F. Reilly, PNT Mining, Inc. Response to Reilly letter of April 15 summarizing Permit 77-367. (Included summary of reclamation requirements.)

State of Colorado, Mined Land Reclamation Division. 1986 (July 1). Letter from C. Farrell, Reclamation Specialist, to B. Knocks, Newport Minerals, Inc. Permit M-77-367: Notice of Board issuance of NOV M-86-036 and Cease and Desist Order for Globe Hill/'76 Project. (Includes NOV and Order; also includes June 3, 1986, letter from D.C. Shelton, MLRD, to B. Knocks, summarizing earlier inspections and Newport's failure to respond).

State of Colorado, Mined Land Reclamation Division. 1986 (July 10). Notice of Inspection and Inspection Report on July 10 inspection of Victor Mine (permit 81-134) by C. Farrell.

State of Colorado, Mined Land Reclamation Board. 1986 (September 4). Notice of Violation M-86-049 and Cease and Desist Order, Permit M-77-367. (For noncompliance with July 1, 1986, NOV M-86-036 and Order).

State of Colorado, Mined Land Reclamation Division. 1986 (September 25). Letter from C. Farrell, Reclamation Specialist, to B. Horn, Dayspring Mining Corporation. Permit M-77-367: Notice of Board approval for Daysprings Mining Corporation to succeed Newport Minerals, Inc., as operator of Globe Hill Project.

State of Colorado, Mined Land Reclamation Division. 1986 (September 29). Letter from D.C. Shelton, Director, to G.P. Reed, Newport Minerals, Inc. Notice of Board issuance of NOV M-86-0057 and Cease and Desist Order for Globe Hill/'76 Project. Issued to Newport Minerals for noncompliance with NOVs M-86-036 (July 1, 1986) and M-86-049 (September 4, 1986) and associated Cease and Desist Orders. (Includes NOV and Order; notes Dayspring Mining Corporation succession as permittee.)

State of Colorado, Mined Land Reclamation Division. 1987a (January 12). Letter from C. Farrell, Reclamation Specialist, to E. Hunter, Nerco Minerals Company. Permit 81-134, Technical Revision 5: notice of completeness for application for Technical Revision 5 and request for clarification of specific items prior to Board consideration.

State of Colorado, Mined Land Reclamation Division. 1987b (January 12). Memorandum to File from A. Baldridge, Reclamation Specialist. Record of telephone conversation with A. Tapp, Cripple Creek and Victor Gold Mining Company, concerning water balance at Victory and Carlton Mill ponds.

State of Colorado, Mined Land Reclamation Division. 1987 (February 26). Letter from C. Farrell, Reclamation Specialist, to E. Hunter, Nerco Minerals Company. Permit 81-134, Technical Revision 5: Notice of February 25 Board approval of Technical Revision TR-05 and incorporation of terms of revision into permit.

State of Colorado, Mined Land Reclamation Division. 1987 (March 26). Letter from A. Baldridge, Reclamation Specialist, to C. Gerity, Cripple Creek and Victor Gold Co. Carlton Project, Permit 80-244, Technical Revision 1: Notice of March 25 Board approval of Technical Revision 1 and additional permit stipulations.

State of Colorado, Mined Land Reclamation Division. 1987 (October 22). Minerals Programs Inspection Report for Victor Mine inspection conducted October 22, 1987, by C.M. Farrell.

State of Colorado, Mined Land Reclamation Division. 1988 (January 25). Letter from J.T. Doerfer, Reclamation Specialist, to C. Gerity, Cripple Creek and Victor Gold Co. Carlton Project, Permit 80-244, Technical Revision 2: Notice of January 21 Board approval of Technical Revision 2 (placement of mill tailings on Pad 1). Includes MLRD staff notes.

State of Colorado, Mined Land Reclamation Division. 1988 (February 9). Letter from J.T. Doerfer, Reclamation Specialist, to C. Gerity, Cripple Creek and Victor Gold Co. Carlton Project, Permit 80-244, Amendment 3: Results of adequacy review of amendment application and request for additional information. (Original application not obtained.)

State of Colorado, Mined Land Reclamation Division. 1988 (February 26). Letter from J.T. Doerfer, Reclamation Specialist, to C. Gerity, Cripple Creek and Victor Gold Co. Carlton Project, Permit 80-244, Amendment 3: Notice of February 24 Board approval of Amendment 3 (expansion of Pad 2 on adjacent hillside). Included stipulation that pre-construction notice be provided.

State of Colorado, Mined Land Reclamation Division. 1988a (May 16). Letter from F.R. Banta, Director, to C. Gerity, Texasgulf Minerals and Metals. Permit M-88-025: Notification of May 12 Board approval of Anchoria Leland Mine Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988b (May 16). Letter from F.R. Banta, Director, to C. Gerity, Texasgulf Minerals and Metals. Permit M-88-026: Notification of May 12 Board approval of Chicago Tunnel 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988 (July 7). Letter from J.T. Doerfer, Reclamation Specialist, to C. Gerity, Cripple Creek and Victor Gold Co. Charlton [sic] Project, Permit 80-244: Notice of July 7 Board approval of Technical Revision 3 (change in liner design of Pad 2 expansion approved in Amendment 3).

State of Colorado, Mined Land Reclamation Division. 1988 (August 16). Minerals Program Inspection Report on August 16, 1988, inspection of Victory Pad (#3), Permit 86-024, by C. Farrell and F.R. Banta. (Following cyanide spill on August 12.)

State of Colorado, Mined Land Reclamation Division. 1988 (September 6). Memorandum to MLRD files from J.T. Doerfer, Reclamation Specialist. Victory Project, Permit 86-024: Documentation of August 15 telephone conversation between J.T. Doerfer and A. Tapp, Cripple Creek and Victor Gold Mining Company, concerning cyanide spill on August 12.

State of Colorado, Mined Land Reclamation Division. 1988 (September 13). Letter from F.R. Banta, Director, to B. Mountford, Dayspring Mining Corporation. Permit 77-367: Transmission of September 9 Minerals Programs Inspection Report for Globe Hill ['76 Project] and notice of Board hearing on possible violations.

State of Colorado, Mined Land Reclamation Division. 1988 (September 22). Letter from F.R. Banta, Director, to B. Mountford, Dayspring Mining Corporation. Permit 77-367: Transmission of Notice of Violation M-88-013 and Cease and Desist Order arising from September 9 inspection of Globe Hill ('76 Project).

State of Colorado, Mined Land Reclamation Division. 1988 (September 22). Letter from F.R. Banta, Director, to C. Gerity, Cripple Creek and Victor Gold Mining Company. Victory Project, Permit 86-024: Transmission of Notice of Violation M-88-015 arising from August 12 cyanide spill. (Includes August 29 notice of Board hearing on possible violation.)

State of Colorado, Mined Land Reclamation Division. 1988 (October 26). Letter from F.R. Banta, Director, to C. Gerity, Texasgulf Minerals and Metals. Permit M-88-064: Notification of October 5 Board approval of Gold Star Pit 112 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988 (November 15). Letter from F.R. Banta, Director, to B. Mountford, Dayspring Mining Corporation. Permit 77-367: Transmission of re-issued Notice of Violation M-88-013 and Cease and Desist Order, originally issued September 21; and order of payment of civil penalty.

State of Colorado, Mined Land Reclamation Division. 1988a (November 28). Letter from F.R. Banta, Director, to T. Aragon, Cripple Creek and Victor Gold. Permit M-89-096: Notification of November 21 Board approval of Ocean Wave Mine Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988b (November 28). Letter from F.R. Banta, Director, to T. Aragon, Cripple Creek and Victor Gold. Permit M-89-097: Notification of November 21 Board approval of Tornado/Raven Mine Dumps 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988c (November 28). Letter from F.R. Banta, Director, to T. Aragon, Cripple Creek and Victor Gold. Permit M-88-098: Notification of November

21 Board approval of Blue Flag Mine Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988d (November 28). Letter from F.R. Banta, Director, to T. Aragon, Cripple Creek and Victor Gold. Permit M-89-099: Notification of November 21 Board approval of Howard Mine Rock Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1988 (December 9). Letter from F.R. Banta, Director, to T. Aragon, Cripple Creek and Victor Gold. Permit M-89-100: Notification of November 21 Board approval of Index Mine Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1989 (April 21). Letter from J.T. Doerfer, Reclamation Specialist, to T. Aragon, Cripple Creek and Victor Gold Co. Carlton Project, Permit 80-244, Technical Revision 4: Notice of April 17 Board approval of Technical Revision 4 (water balance information for 1989 operating year).

State of Colorado, Mined Land Reclamation Division. 1989 (July 14). Letter from L.D. Oehler, Reclamation Specialist, to T.L. Aragon, Texasgulf Minerals and Metals. Permit M-89-A059: Notification of July 14 Board approval of Rigi Mine Rock Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1989a (July 27). Letter from F.R. Banta, Director, to C. Gerity, Texasgulf Minerals and Metals. Permit M-89-060: Notification of July 28 Board approval of Upper Mary McKinney Mine Dump 110 permit. Includes permit application and correspondence, including reports on cribbing wall and closure report.

State of Colorado, Mined Land Reclamation Division. 1989b (July 27). Letter from F.R. Banta, Director, to C. Gerity, Texasgulf Minerals and Metals. Permit M-89-061: Notification of July 28 Board approval of Hull City and Sacramento Mine Dumps 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1990 (August 14). Minerals Programs Inspection Report for Victor Mine (Permit 81-134) inspection conducted August 14, 1990, by D.I. Hernandez.

State of Colorado, Mined Land Reclamation Division. 1990a (October 2). Letter from F.R. Banta, Director, to J.P. Rovedo, Cripple Creek and Victor Gold. Permit M-90-109: Notification of Director, to J.P. Rovedo, Cripple Creek and Victor Gold. Permit M-90-109: Notification of October 1 Board approval of Bertha B/Maggie Mine Dumps 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1990b (October 2). Letter from F.R. Banta, Director, to J.P. Rovedo, Cripple Creek and Victor Gold. Permit M-90-110: Notification of October 1 Board approval of Midget Mine Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1990c (October 2). Letter from F.R. Banta, Director, to J.P. Rovedo, Cripple Creek and Victor Gold. Permit M-90-111: Notification of October 1 Board approval of Moon Anchor Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1990 (October 29). Letter from D. Hernandez, Reclamation Specialist, to J.P. Rovedo, Nerco Minerals Company. Permit M-81-134: Notice of Board approval on October 17 of September 20 (dated September 17) request to reactivate Victor Mine.

State of Colorado, Mined Land Reclamation Division. 1991 (January 29). Letter from J.T. Doerfer, Reclamation Specialist, to J.P. Rovedo, Cripple Creek and Victor Gold Mining Company. Permit M-77-367, NOV M-88-013: Approval of actions, proposed in letter of January 23, to respond to NOV 88-013, upon succession of CC&V as operator (from Dayspring).

State of Colorado, Mined Land Reclamation Division. 1991 (February 6). Approval of Transfer of Permit and Succession of Operators Application Form. (Pikes Peak Mining Company succeeded Daysprings Mining Corporation as operator of Globe Hill/Bull Hill.)

State of Colorado, Mined Land Reclamation Division. 1991 (August 5). Minerals Programs Inspection Report for Victor Mine (Permit 81-134) inspection conducted August 5, 1991, by T. Schreiner.

State of Colorado, Mined Land Reclamation Division. 1991 (October 10). Letter from T.A. Schreiner, Reclamation Specialist, to J.P. Rovedo, Pikes Peak Mining Company. Permit 77-367, Globe Hill Mine: Notice of Board approval for Technical Revision 4 (Install double-lined leach pad where existing Forest queen leach pad was currently in place). Includes application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1991 (November 7). Letter from D.L. Bucknam, Acting Director, to E.T. Hunter, Cripple Creek and Victor Gold. Permit M-91-114: Notification of November 6 Board approval of Clyde/Modoc Dump 110 permit. Includes permit application and correspondence.

State of Colorado, Mined Land Reclamation Division. 1992 (February 27). Minerals Programs Inspection Report for Victor Mine (Permit 81-134) inspection conducted February 27, 1992, by C.B. Mount (following Ironclad heap pregnant cyanide solution spill beginning on February 26).

State of Colorado, Mined Land Reclamation Division. 1992 (March 2). Minerals Programs Inspection Report for Victor Mine (Permit 81-134) inspection conducted March 2, 1992, by C.B. Mount and B. Keffelow (following Ironclad heap failure and solution flow).

State of Colorado, Mined Land Reclamation Division. 1992 (April 3). Letter from M.B. Long, Director, to E.T. Hunter, Nerco Minerals Company. Permit M-81-134: Notice of Board issuance of Notice of Violation M-92-022 and assessment of civil penalty ($350) for cyanide spill on February 26.

State of Colorado, Office of the State Engineer, Division of Water Resources. 1991 (July 30). Memorandum from D.L. Nettles, Water Resources Engineer, to D.I. Hernandez, Mined Land Reclamation Division. Permit M-81-134, Victor Mine Amendment: Recommendation against approval of Victor Mine amendment (Nerco 5/10/91) pending resolution of water rights.

Teller County, Colorado. 1988 (August 22). Letter from R.E. Bergman, Teller County Commissioners, to G. Tuffino, Vice President, Texasgulf Mining and Materials, Inc. (Letter citing August 12 cyanide spill and requesting immediate notification in case of future incidents.)

Texasgulf Minerals and Metals, Inc. 1988 (September 19). Letter from T.L. Aragon, Legal Counsel, to D. Holder, Colorado Mined Land Reclamation Division. Victory Project, MLRD Permit 86-024:

Response to MLRD letter of August 29, 1988, advising Texasgulf of Board hearing on possible violation (August 12 cyanide spill).

Texasgulf Minerals and Metals, Inc. 1989 (March 16). Letter from T.L. Aragon, Legal Counsel, to J. Doerfer, Colorado Mined Land Reclamation Division. MLRD Permits 80-244 (Carlton Mill Pad 2) and 86-024 (Victory Project Pad 4): Water balance information. Subsequently approved as Victory Project Technical Revision 5 and Carlton Mill Project Technical Revision 4.

Texasgulf Minerals and Metals, Inc. 1989 (April 14). Letter from T.L. Aragon, Legal Counsel, to J. Doerfer, Colorado Mined Land Reclamation Division. Victory Project, MLRD Permit 86-024: Copies of internal Texasgulf reports on cyanide spills on April 11 and 12.

Texasgulf Minerals and Metals, Inc. 1989 (May 10). Letter from T.L. Aragon, Legal Counsel, to J. Doerfer, Colorado Mined Land Reclamation Division. Victory Project, MLRD Permit 86-024: Topsoil/Growth medium balance information and proposed replacement plan. (Includes MLRD and Texasgulf correspondence culminating in MLRD's 12/6/89 approval of Technical Revision for reclamation of the Portland Pit; does not include 8/30/89 Technical Revision application.)

Texasgulf Minerals and Metals, Inc. 1989 (July 24). Internal Texasgulf memorandum from W.S. Moser to J.S. Burt. Victory Project, Permit 86-024: "De Minimus Solution Spill on Pad #4, July 23, 1989."

Thompson, T.B. 1992 (February). "Mineral deposits of the Cripple Creek district, Colorado." *Mining Engineering* (February 1992), pp. 135-138.

APPENDIX 4-A

PERMIT HISTORY OF THE CARLTON MILL HEAP LEACH PADS (MLRD PERMIT 80-244)

Permit History of Carlton Mill Project Heap Leach Pads 1 and 2 (MLRD Permit 86-024)		
Date	**Event**	**Description**
1980 (application not obtained	Permit application/ approval	69.7 acres. Previously had been conventional flotation mill. Tailings were disposed in impoundment immediately below mill area. Active from early 1950s through 1962, then briefly in 1982. Extent of 1980s operations as conventional mill was not determined.
May 30, 1985 (CC&V 3/12/85; MLRD 5/30/85)	Amendment 1	Add heap leach pad and recovery system. Use Cresson and Gold Sovereign mine dumps as sources of 150,000 tons of ore for Carlton Mill leach pad (no. 1) in 1985 season. Crushing to occur at pad. Seasonal leaching, six months per year. Only preliminary design presented in amendment application. • Two double-lined pads planned but actually constructed as single pad: planned sizes were 147,750 and 167,000 ft^2 with maximum slope of 10 percent (requiring cutting and filling, removal of old tailings and soil); actual size of single pad not determined but described as "slightly larger." Maintain 20-foot unstacked apron on liner around heap. Liners not described. Nominal design: four cells divided by internal (below liner) berms; each to be leached separately. Pads immediately uphill of existing tailings impoundment. French drains were installed under pad to lower water table. • Crush ore to 0.5 - 1 inch, add cement and cyanide agglomeration, convey to stacker or loader on heap. • Sprinkler application of sodium cyanide solution at 217 (150-250) gpm: First applied to primary module, then to secondary module, then conveyed to pregnant pond and recovery. Modules leached for 30-45 day period. • Four ponds: double-lined barren and intermediate working ponds plus pregnant and backup ponds--liners not described. Each pond to measure (nominally) 100 x 100 x 12 feet, with 544,000 gallon capacity. Total capacity sufficient for process solutions and 100-year/24-hour storm. Area immediately downslope of ponds (upper end of old tailings impoundment) bermed to serve as emergency catchment area. • Gold recovery in portable columns in adjacent concrete-lined and -curbed area; then, in Carlton Mill building, pressure caustic stripping, electrolytic plating onto stainless steel wool, smelting to doré. Rates not specified. • 200-pound cyanide barrels to be triple-rinsed, crushed, landfilled (at unspecified site). • Entire area fenced with barbed wire, with chain link fence around ponds. • Water obtained from town of Victor. • Reclamation--Heap: Reclaim in place. Detoxify to "acceptable quality," grade side slopes to 2H:1V, compact and slope upper surface to promote runoff. Ponds: Puncture, fold, and backfill. Re-spread salvaged topsoil on ponds and other areas but not heaps (insufficient topsoil), mulch, fertilize, and seed. • Required to monitor pad/ponds and downgradient areas for metals and other parameters.

Permit History of Carlton Mill Project Heap Leach Pads 1 and 2 (MLRD Permit 86-024)		
Date	**Event**	**Description**
March 24, 1986 (CC&V 1/16/86; MLRD 3/24/86; Dames & Moore 1986)	Amendment 2	• Increase permitted area to 116.1 acres by adding more old mine dumps as sources of ore. Additional $9,700 bond for total of $75,000. • Add another 150,000 tons to Pad 1. • Construct another heap leach pad (Pad 2) and pregnant pond immediately downgradient from Pad 1, on top of Tailings Dam No. 1 impoundment. Use Pad 1 pond for barren pond. Use area mine dumps as source of ore. Crush and agglomerate at dumps or on-site. • Tailings on which heap to be constructed ranged from 7 to 74 feet deep. Saturated at depths of 30 feet (under center of impoundment) to 45 feet (near dam). There was a 12-inch pipe on west abutment with continuous slow seepage. Consultant recommended plugging with grout. Not determined if actually plugged. • Heap to reach 100 feet height, four 25-foot angle of repose lifts set back 25 feet between lifts, for 2H:1V side slope. Total lined pad 320,000 ft^2, with 20-foot heap setback. Single 80-mil HDPE liner, with old tailings to serve as secondary liner. It was anticipated that the tailings under the heap, and thus the base of the heap, would settle about three feet near the center of the heap. Pad was to be sloped to maintain positive drainage. Plans were to add about 250,000 tons of ore per year through 1989. Capacity: "600,000 tons or more." • Pregnant pond: Double-lined, excavated into tailings--liners not described. Remainder of tailings impoundment below pond (i.e., to raised dam) described as potential emergency storage, as was Dam 2 impoundment immediately downgradient. Capacity of lined pond about 2,120,000 gallons plus one foot freeboard. Unlined area in Dam 1 impoundment provided an additional 827,000 gallon capacity. • Consultant recommended: place pneumatic piezometers in tailings, establish survey monuments on pad liner ahead of ore placement, and slope indicators between heap and pond. Not known if installed/implemented.
April 20, 1987 (CC&V 4/27/87)	Cyanide spill	Coupling hose for portable carbon column separated and total of 7,500 gallons (500 gpm for 15 minutes) of cyanide solution escaped. Cyanide concentration was less than 0.5 pounds per ton of solution. Most (5,500 to 6,500 gallons) were contained in outdoor concrete-lined and -curbed area, from which solution drained to solution ponds. About 1,000 to 2,000 gallons overtopped curb and flowed across unlined surface 300 feet to unlined emergency storage pond, where it was diluted with 1,500,000 gallons of stored storm water. No solution reached off-site areas. Cleanup of flowpath not described. Remedies included regrading and installation of automatic shutoff devices.

Permit History of Carlton Mill Project Heap Leach Pads 1 and 2 (MLRD Permit 86-024)		
Date	**Event**	**Description**
March 26, 1987 (CC&V 2/23/87a; MLRD 3/23/87)	Technical Revision 1	1987 plans for Pad 2: • Add an additional 500,000 tons of leach ore to 1986's 462,000 tons. Stack ore to height of 130 feet or extend lined pad to north to within 20 feet of a ditch between this pad and Pad 1. This would result in an additional three inches of settling of the pad. • Also add additional water capacity: to use unlined top of tailings impoundment (on which the pad is constructed) and an additional 3,500,000 gallon unlined emergency pond below the dam of the tailings impoundment. The latter required improvements to the crest of the lower tailings impoundment dam (dam 2). In approval, MLRD required notice if unlined areas were actually used to store water.
October 8, 1987 (CC&V 11/3/87)	Cyanide spill	Spray header on Pad 2 broke, creating washout on northwest side of pad. Washed-out toe reached to within three feet of liner edge and some solution ran off pad. 20-gallon puddle off the liner resulted. Sampling (no results presented) showed cyanide in the solution but not the soil. Cyanide was neutralized (no details provided) and followup sampling showed no detectable cyanide in soils.
November 1987 (CC&V 11/19/87)	Leak in primary liner of Pond 4	Noted that cyanide had been detected in the leak detection system of Pond 4 on an unspecified date during 1986 (?) operating system. The pond had been removed from operation. After emptying pond, several holes in primary liner were discovered and repaired. Secondary (lower) liner was intact. Pond was to be returned to service in 1988.
January 1988 (CC&V 11/20/87, MLRD 1/25/88)	Technical Revision 2	• Rehabilitate portions of Carlton Mill circuit: receiving, crushing, surge capacity, grinding, and thickening. • Install new six-stage carbon-in-leach circuit with capacity of 150 tons per day. To use mill for high-grade ore stockpile. To grind to 80 percent -325 mesh. • Slurry a total of 25,000 tons of tailings (about 45 percent solids) from mill to top of heap leach Pad 1. Excavate and construct (via berms) an unlined "pond" on the top surface of the pad for tailings disposal. Decant water to be recycled to mill. • Geotechnical studies indicated that tailings would not filter through leached ore material in appreciable amounts but fluids would leach through for collection in existing Pond 4. • No change in reclamation requirements. Fine mill material was thought to be more amenable to revegetation without topsoil amendments.
February 1988 (MLRD 2/9/88 and 2/26/88; CC&V 2/22/88)	Amendment 3	Application for amendment not obtained. References include MLRD adequacy review and CC&V response. • Expand Pad 2 to 440,820 ft^2, with lined "spray apron" of 20 feet around heap. To leach about 200,000 tons of ore in one 50-foot lift in the expansion area. Expansion to extend up adjacent hillside, which required innovative liner-joining techniques. • Added 7.9 acres to permit area, for total of 130 acres.

Permit History of Carlton Mill Project Heap Leach Pads 1 and 2 (MLRD Permit 86-024)		
Date	**Event**	**Description**
July 1988 (MLRD 7/7/88; CC&V 5/31/88a)	Technical Revision 3	Redesign of leak detection system for expansion of Pad 2 approved with Amendment 3. Originally, liner was to be laid on the steep slope in upper and lower sections, with leak detector drains at toes of both sections. Redesign led to installation of liner in a single section, thus eliminating the drain below the upper section. The nature of subgrade actually encountered (some hard rock, some rocky colluvium) made original design infeasible. Also, angular cobbles made it necessary to change from 16-ounce geotextile underlayer (for liner cushion) to a layer of old tailings.
April 1989 (CC&V 3/16/89; MLRD 4/21/89)	Technical Revision 4	Water balance information for 1989 operating season. No change in pond capacity required (existing ponds sufficient for operating volumes, 100-year/24-hour storm, and some heap desaturation).
June 1990 (Pikes Peak 4/27/90; MLRD 6/22/90)	Technical Revision 5	Changes to water quality monitoring requirements. Requirements include sampling of: • Arequa Gulch upstream and downstream of Carlton Mill • Pad 1 French drain • Six "ground-water" monitoring wells in tailings below Pad 2. Semiannual monitoring of full suite of parameters; monthly for pH and WAD, free, total CN. Parameters include dissolved, not total, metals.

APPENDIX 4-B

PERMIT HISTORY OF THE VICTORY PROJECT (MLRD PERMIT 86-024)

Permit History of Victory Project Pads 3 and 4 and Portland Pit (MLRD Permit 86-024)		
Date	**Event**	**Description**
February 21, 1986 (CC&V 2/21/86)	Permit application	34.5 acre cyanide heap leach operation 0.5 miles north of Victor, 1.5 miles SE of Ironclad/Globe Hill facility. On ridge of Battle Mountain. • Nearby mine dumps to serve as sources of ore. Seasonal operation, April through November. • Most of site void of vegetation and covered with old tailings (from inches to "tens of feet" thick). • One pad: 381,000 square feet, including 20-foot "safety apron." 1,000,000 ton capacity, 360,000 tons expected during 1986. Less than 10% average slope, < 20% maximum. Double lined (80-mil HDPE over compacted old tailings). All pipes six-inch or less PVC. • Heap to be constructed in lifts: 35 feet in 1986, subsequently 10-12 foot lifts to final height of about 100 feet. • Recovery plant: portable carbon columns for adsorption, with loaded carbon trucked to Carlton Mill for stripping, etc. • Three ponds with total capacity of 4,090,000 gallons, sufficient for 100 year/24-hour storm plus operating volumes. 500-550 gpm spray rate at 0.004 gpm/ft^2. All ponds double-lined and surrounded by dikes/berms. Construction required substantial cut and fill. Ponds include: 1,680,000 gallon barren 1,040,000 gallon pregnant 1,775,000 gallon emergency storage pond 598,000 gallon emergency overflow capacity (also lined). • Barbed wire fence around entire area, chain link fence around ponds. • All upslope run-off diverted around site and unspecified number of old mine openings sealed. • Required to sample surface water in North Fork of Wilson Creek semi-annually. • Reclamation: detoxify heap until effluent reaches unspecified "acceptable quality", contour slopes to < 2H:1V. Backfill and revegetate ponds but not heap. • $21,500 bond.
January 1987 (MLRD 1/12/87)	Excess water	500,000 gallons of water hauled from Victory emergency pond to Carlton Mill Pond 1.
February 23, 1987 (CC&V 2/23/87b and 5/26/87)	Technical Revisions 2 and 3*	• Enlarge pad for 1987 operations. • 416,000 tons had been stacked in 1986, 430,000 more tons to be added in 1987, in 25-foot lifts. Pad area covered 291,980 ft^2. • Increase pond capacity by adding 4-foot lined berm around ponds: to add 2,392,000 gallons additional storage, to a total of 7,485,000 gallons. Ponds covered 79,980 ft^2.

Permit History of Victory Project Pads 3 and 4 and Portland Pit (MLRD Permit 86-024)		
Date	**Event**	**Description**
July 1987 (CC&V 7/17/87 and 12/8/87; Dames & Moore 3/16/89)	Amendments 1 and 3	• Add 49.83 acres to permit (including 21.27 acres from permit 86-009) for new Pad 4. Much of area covered with old tailings and waste rock. Constructed in 1988. • New 15 acre heap leach pad (Pad 4 or Portland Pad), to be constructed in four subcells. Partially built on top of waste rock dumps, including new rock from Portland pit (see amendment 2 below). Double-lined pad (60-mil HDPE, granular tailings with 3-inch pipes as drainage layer, and 80-mil HDPE) constructed on base of compacted tailings. Pad covers 660,000 ft^2, capacity of about 1,825,000 tons. • Ore from old dumps in area and new pit (see amendment 2 below) • Part of pad drains to Pad 3 ponds, part to three new ponds: 1,935,000 gallon pregnant, 491,500 gallon barren, 1,616,000 gallon emergency overflow ponds. All have double 60-mil liners with geotextile leak detection system. Later described as having 6,300,000 gallon capacity (Texasgulf 3/16/89), presumably reflecting expansions for which documents not obtained for this report. All six ponds for Pads 3 and 4 connected by pipes for gravity/pumping flows. • 12 old shafts in construction area filled with gravel and compacted. One large shaft remained between pad and ponds. • Reclamation: similar to Pad 3. • 672,000 tons placed on Pad 4 in 1988; one lift 8-30 feet high, averaging 20-25 feet (Texasgulf 3/16/89).
August 1987 (CC&V 8/12/87)	Amendment 2	Add 28.18 acres to permit (including 9.94 from another permit). • Construct open pit mine, the Portland Pit, adjacent to and downhill of Pad 4. • Expected to reach 500 feet (east to west) by 1,400 feet (north to south) by 240 feet deep. Waste:ore ratio of about 2.5:1---predicted 500,000 tons ore and 1,300,000 to 1,500,000 tons waste rock. About 600,000 tons waste rock used for fill in Pad 4 construction. • Waste rock at angle of repose on hillside. Some minor smooth grading anticipated for reclamation. • Reclamation: Safety/warning bench about 15 feet below top; remainder benched as recommended by MSHA. Re-soil and vegetate benches and pit floor if sufficient topsoil or other medium is salvaged.
December 1987 (CC&V 12/18/87)	Solution in leak detection system, Pad 3	On December 5, CC&V noted solutions flowing out of leak detection pipe on Pad 3: analyses showed high (but unspecified) cyanide, pH, and gold. On December 6, shut down spray on that portion of heap; within 24 hours, flow had slowed significantly. Notified MLRD on December 7. CC&V attributed flow to tear in primary liner along seam where expansion joined original construction; "probably" the result of late-season slough (otherwise undescribed). CC&V planned to leave this area unsprayed, then try to find and fix leak. CC&V noted a "remote possibility" of permanently shutting down this part of heap. No further information obtained.

Permit History of Victory Project Pads 3 and 4 and Portland Pit (MLRD Permit 86-024)		
Date	**Event**	**Description**
May 31, 1988 (CC&V 5/31/88)	Technical Revision 4	Construct haulage road across bench on face of Pad 3 to provide easier access to Pad 4.
July 5, 1988 (CC&V 7/21/88)	Damage to pads and ponds	Errant blast in Portland Pit: fly rock punctured primary liners in Pads 3 and 4 and in five of the six solution ponds. All being repaired. Attributed to use of "extra powder" in wet blastholes.
August 12, 1988 (MLRD 8/16/88, 9/22/88b)	Cyanide spill	1,500 to 2,000 gallons of barren solution spilled from pipe ruptured by loader. Flow followed gully off-site for 300 yards before entering abandoned mine shaft. Led to NOV M-88-015. Described in chapter 4 text.
March 16, 1989 (Texasgulf 3/16/89)	Technical Revision 5	Water balance information for 1989 operations: Total storage volume needed for 100-year/24-hour storm containment plus operating volumes calculated at 13,064,000 gallons, compared to 13,400,000 gallons actual capacity in Pads 3 and 4 ponds.
April 11, 1989 (Texasgulf 4/14/89)	Cyanide spill	Cracked pipe (the result of freezing) spilled up to 2,880 gallons (3 gpm for 16 hours) of pregnant solution. Solution contained 0.65 pounds sodium cyanide per ton of solution, so up to 7.75 pounds of NaCN were involved. Most solution was contained by the Pad 4 pond liner system but some escaped into pond embankment material. Area treated with calcium hypochlorite.
April 12, 1989 (Texasgulf 4/14/89)	Cyanide spill	Hose emptying barren solution into mix tank fell out of tank and landed across the curb that surrounded the cement pad near heap leach Pad 3. About 3,000 gallons of barren solution (0.45 pounds cyanide per ton of solution, pH about 10.2) ran across the ground for 50 feet, where the flow entered the lined Pad 3 solution ponds.
July 23, 1989 (Texasgulf 6/24/89)	Cyanide spill	Some unspecified cause resulted in flow from a "blown 1/2-inch dripper line" leaving the pad (via an old access ramp) and trickling 40 to 50 yards down the road to the east. An estimated 240 gallons containing 0.8 pounds cyanide escaped. Five pounds of calcium hypochlorite in a water solution was applied to the flowpath.
September 11, 1989 (Nerco 8/22/90)	Change in name	Nerco changed name of Texasgulf Minerals and Metals to Pike's Peak Mining Company (changed to "Pikes Peak" in 1990). It should be noted that Nerco's 100 percent purchase of Texasgulf from ELF Aquitane was not effective until August 31, 1990, nearly a year after Nerco changed the name of Texasgulf.
May - December 1989 (Texasgulf 5/10/89)	Technical Revision (6?)	Reclamation plan for Portland Pit. Texasgulf reported 30,000 yd^3 of old tailings and topsoil had been salvaged and stored. It was proposed to place this on waste dump, areas of process ponds, pit benches and floor, and other disturbed areas prior to revegetation. No revegetation of Pads 3 and 4 heaps planned. (Note: Final plans not obtained.)
January 9, 1990 (CC&V 2/12/90)	Cyanide spill	Ice buildup in ditch around a Pad 4 pond blocked ditch flow and solution flowed onto and over surrounding berm. Flow did not reach bottom of berm. About 500 gallons (1.04 pounds sodium cyanide, pH of 9.6) was involved. Neutralized with calcium hypochlorite; intended to raise berm by 2-3 feet.

Permit History of Victory Project Pads 3 and 4 and Portland Pit (MLRD Permit 86-024)		
Date	**Event**	**Description**
April 27, 1990 (Pikes Peak Mining Company 4/27/90)	Technical Revision 9*	Improve water quality monitoring. Sample Wilson Creek upstream and downstream of Victory Project: semi-annual monitoring of full suite of parameters (Free CN, pH, nitrate, nitrite, and metals). Included data from 1987, 1988, and 1989.
November 5, 1990 (CC&V 11/5/90)	Cyanide spill	100 gallons containing 0.52 pounds CN per ton of solution "got off the edge of the pad liner" of Pad 4. No other details on cause or extent of spill were provided. The spill was neutralized with two pounds of hypochlorite.

* Technical revision one not obtained. Of technical revisions 6, 7, and 8, only one was obtained.

APPENDIX 4-C

COMMENTS SUBMITTED BY NERCO MINERALS COMPANY ON DRAFT SITE VISIT REPORT

The letter reproduced in this appendix accompanied a copy of the draft site visit report on which Nerco Minerals Company had made comments and corrections. A copy of the marked-up draft is not reproduced here for brevity's sake. In general, Nerco's comments were clarifying in nature, providing information that the draft report indicated had not been obtained during the site visit or correcting minor factual errors in the draft. EPA's response to Nerco's comments are provided in Appendix 4-D

[Comments not reproduced for this electronic version. Copies may be obtained from U.S. EPA, Office of Solid Wastes, Special Waste Branch.]

APPENDIX 4-D

EPA RESPONSE TO COMMENTS SUBMITTED BY NERCO MINERALS COMPANY ON DRAFT SITE VISIT REPORT

EPA Response to Comments Submitted by
Nerco Minerals Company
on Draft Site Visit Report

EPA has revised the report to incorporate all of the comments and suggestions made by Nerco Minerals Company. In some cases, EPA made minor changes to wording suggested by Nerco in order to attribute the changes to Nerco or to enhance clarity.

MINE SITE VISIT:

NEWMONT GOLD COMPANY
RAIN FACILITY

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street SW
Washington, DC 20460

5.0 SITE VISIT REPORT: NEWMONT GOLD RAIN

5.1 INTRODUCTION

5.1.1 Background

The U.S. Environmental Protection Agency (EPA) is assisting states to improve their mining programs. As part of this ongoing effort, EPA is gathering data related to waste generation and management practices by conducting site visits to mine sites. As one of several site visits, EPA visited the Newmont Gold Company Rain facility near Carlin, Nevada, on August 20 and 21, 1991.

Sites to be visited were selected by EPA to represent both an array of mining industry sectors and different regional geographies. All site visits have been conducted pursuant to RCRA Sections 3001 and 3007 information collection authorities. Although Newmont Gold Company disputes EPA's authority to proceed under those sections of RCRA, Newmont Gold cooperated with EPA in connection with the Rain site visit. When sites have been on Federal land, EPA has invited representatives of the land management agencies [Forest Service/Bureau of Land Management (BLM)]. State agency representatives and EPA regional personnel have also been invited to participate in each site visit.

For each site, EPA has collected information using a three-step approach: (1) contacting the facility by telephone to get initial information, (2) contacting State regulatory agencies by telephone to get further information, and (3) conducting the actual site visit. Information collected prior to the site visit is reviewed during the visit to ensure accuracy.

In preparing this report, EPA collected information from the State of Nevada and Newmont Gold Company. The Nevada Department of Environmental Protection (NDEP) provided information relating to the Rain facility's Water Pollution Control Permit and associated records including the Final Environmental Assessment (Newmont Services, 1987b), design reports, correspondence, and informal communication with NDEP personnel. EPA also obtained information from telephone interviews with Newmont and NDEP personnel. The following individuals participated in the Newmont Rain facility site visit:

Newmont Gold Company

Dave Baker, Vice President, Environmental Affairs	303-837-5885
Eric Hamer, Vice President, Newmont Nevada Operations	702-778-4252
Steve Winkelmann, General Superintendent	702-778-4526
Pat Lorello, Environmental Compliance for Nevada Operations	702-778-4139
John Mudge, Mill Superintendent	702-778-4577
Kurt Criss, Senior Mine Engineer	702-778-4885
Mark Raffman, Attorney (Shea & Gardner)	202-775-3017
John Jory, Geologist	702-778-4507

State of Nevada

Doug Zimmerman, Division of Environmental Protection	703-687-4670
Dennis Anderson, Department of Mines	702-687-5050
Rory Lamp, Department of Wildlife	702-738-5332

Bureau of Land Management

Nick Rieger, Physical Scientist	702-753-0200

U.S. EPA/Office of Solid Waste

Steve Hoffman, Chief, Mine Waste Section	703-308-8413
Patti Whiting, Environmental Protection Specialist	703-308-8421

Science Applications International Corporation

Jack Mozingo, Environmental Scientist	703-734-2513
Joseph Rissing, Geologist	703-734-4366

Participants in the site visit were provided an opportunity to comment on a draft of this report. Comments made by Newmont Gold Company are presented in Appendix 5-E. EPA responses to comments by Newmont are in Appendix 5-F.

5.1.2 General Description

The Rain facility, owned and operated by Newmont Gold Company, is located approximately 9 miles southeast of Carlin in Elko County, Nevada (see Figures 5-1

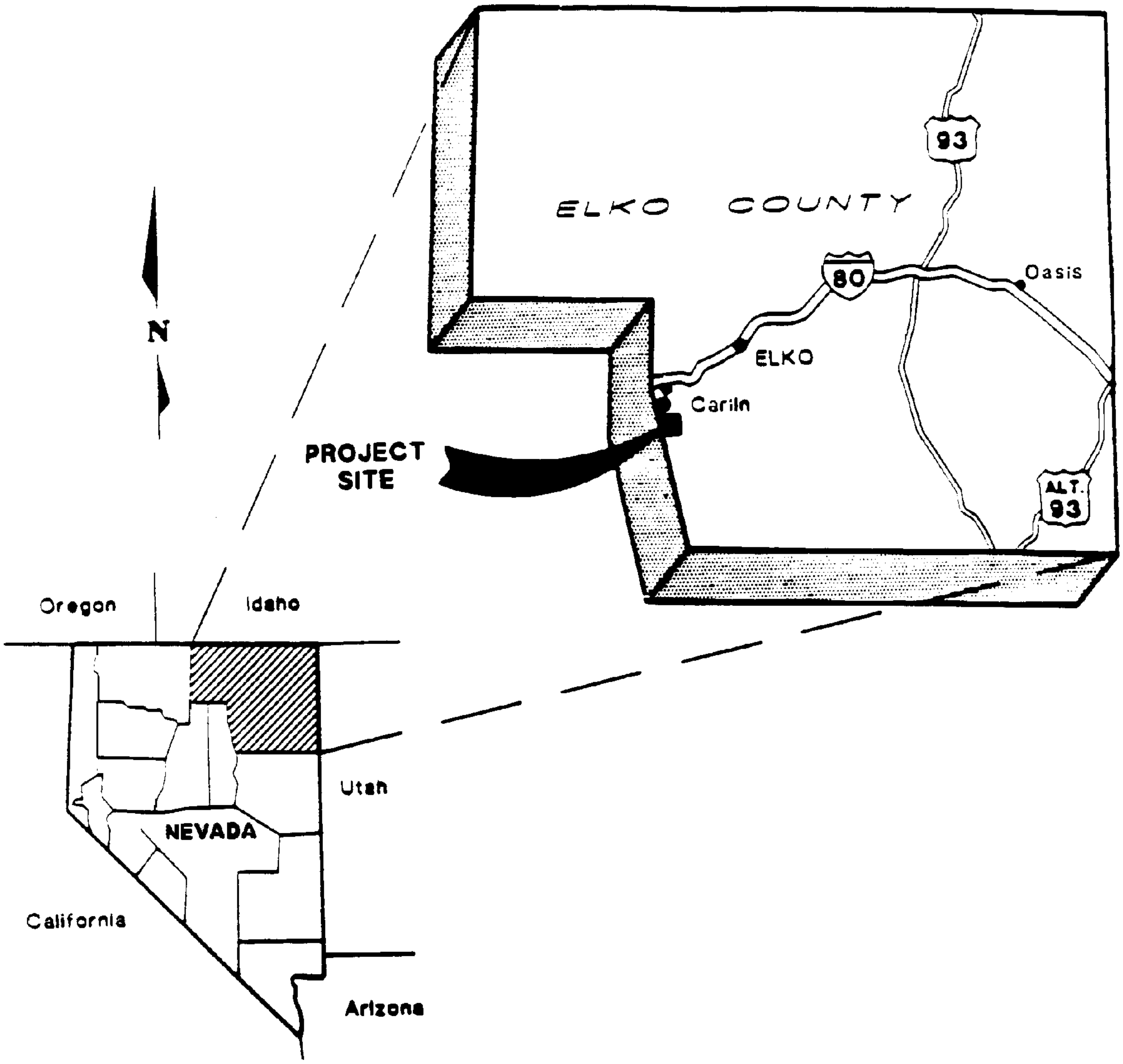


Figure 5-1. Site Location Map

(Source: SRK 1990)

and 5-2). Access to the facility from Carlin is by Ridge Road, which was widened and straightened by

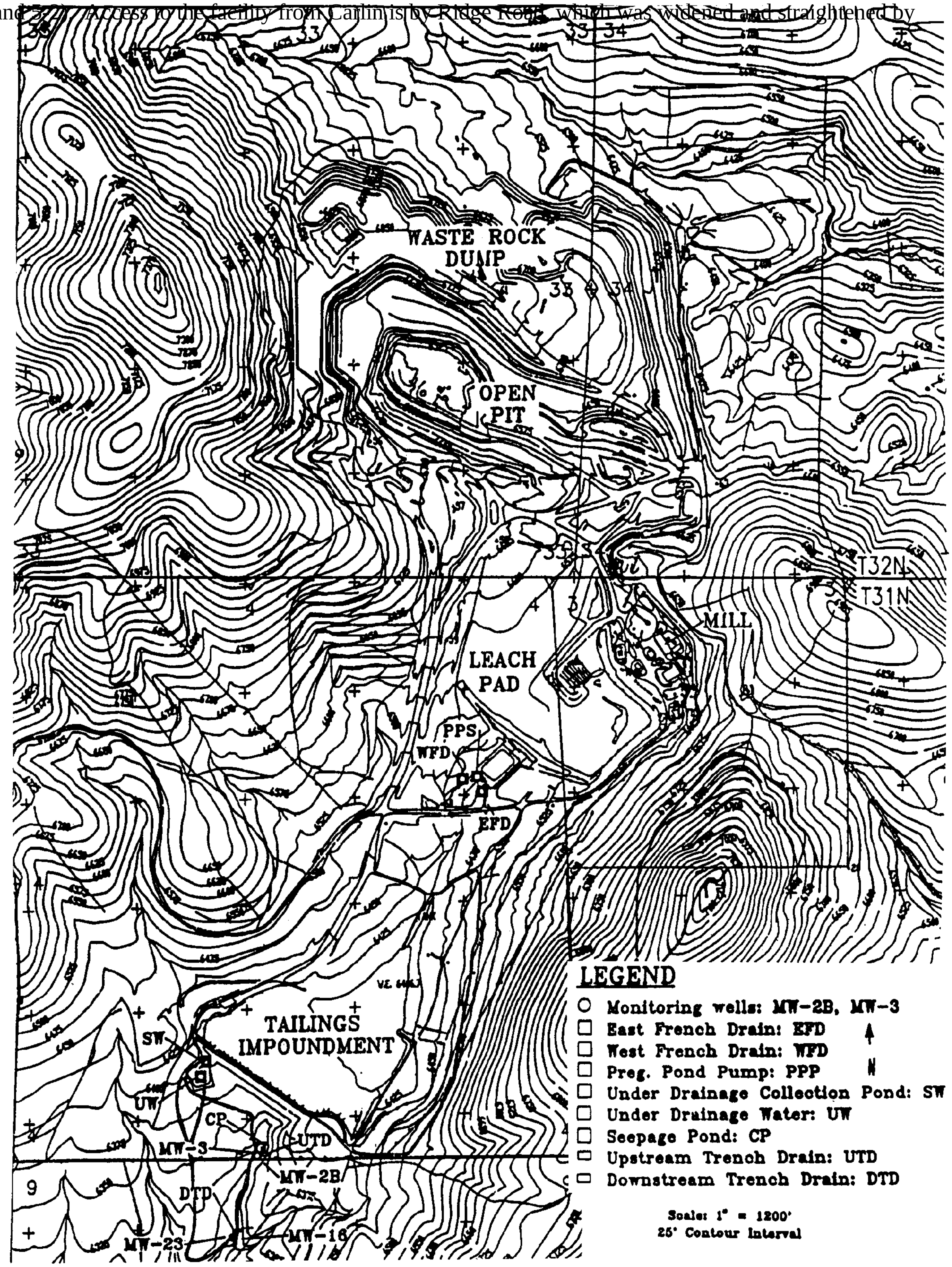


Figure 5-2. Location of Rain Facilities

(Source: Newmont Gold Company)

Newmont during the development of the Rain facility. The road is approximately 14 miles long and crosses BLM lands that are allocated for grazing. This road is well maintained and is bermed along much of its length to control run-off. Diversions and culverts in drainageways serve to minimize run-on. Fugitive dust is controlled by watering with added surfactant. A power line to the facility generally follows the road.

The facility is a mining-milling-leaching operation for beneficiating disseminated gold ore. Ore and waste rock are mined from an open pit. Waste rock is material that does not contain sufficient gold values to justify milling or leaching, and is removed to access the ore. According to the final environmental assessment (Newmont Services, 1987b) 47.6 million tons (all tonnage figures in short tons) of material were planned to be removed from the pit from 1988 project startup through the projected 8-year life span of the mine. Of the total projected volume, approximately 10.1 million tons was expected to be ore grade and 37.5 million tons waste rock. As of October 1990, these figures had been revised: projected waste rock tonnage was estimated to be 41.4 million tons by the end of 1990, and 62.5 million tons during the life of the mine, at a stripping ratio of 3.55:1. Of the ore removed from the mine, over forty percent is milled and beneficiated by the carbon-in-leach method at a current rate of about 840,000 tons per year (TPY). The remaining ore (about 1,000,000 tons per year) is leached using a modified heap method referred to as a valley leach (SRK, 1990).

The facility is located on approximately 627 acres covering parts of four Sections (see Figure 5-2). During the site visit, Newmont explained the distribution of surface and mineral rights to the land held by the BLM and private parties as follows: Newmont Gold Company holds the surface rights in T32N, R53E, Section 33, and T31N, R53E, Section 4; a private party holds the mineral rights to these Sections. These Sections are the current location of the pit, leach pad, and tailings impoundment, and a portion of the waste rock dump. Newmont Gold Company holds the mineral rights for T32N, R53E, Section 34; BLM holds the surface rights to this Section. An ore stockpile and the remainder of the waste rock dump are located in this Section. Private parties hold both surface and mineral claims to T31N, R53E, Section 3; most of the mill facility is located in the northwest quarter of this Section.

5.1.3 Environmental Setting

The Rain facility is located near the northern end of the Great Basin Physiographic Province, in the Pinon Mountain Range, part of the area known as the Carlin Trend. It is 90 miles east of the Central Nevada Seismic Zone. The facility is at an elevation of approximately 6,600 feet above sea level (asl) between Rain Peak (elevation 7,403 feet asl) on the west and Snow Peak (7,128 feet asl) on the east. The mine pit is situated on the east flank of Rain Peak, the east side is the lower elevation at 6,575 feet, the west side is at 7,000 feet. The mill complex and ore stockpiles are located in the saddle area between the peaks. The waste rock dump is located on the north side of the saddle above the Emigrant Springs drainage. The tailings impoundment is on the southwest side of the saddle below the mill in the ephemeral headwaters of Ferdelford Creek (Figure 5-2).

Soils in the project area are made up of both aridisols and mollisols, typically having accumulations of clay and/or calcium carbonate below the surface. Parent materials include andesite and rhyolite from volcanic sources and shale, sandstone, and conglomerate from sedimentary sources. Native vegetation consists of sagebrush, cheatgrass, and bluegrass. Cattle grazing is the primary land use in the area; during the site visit, several cattle were observed along the access road and a cattle trough was observed in the Emigrant Springs drainage between the waste rock dump and Emigrant Springs.

5.1.3.1 Climate

The Rain facility, like all of Nevada, is dominated by continental air masses. High solar energy input and no consistent moisture source result in a dry, warm climate. Precipitation events are typically in the form of thunderstorms in warmer months and snow squalls during the winter. December is typically the wettest month. Annual precipitation at the site averages 12 inches. The average annual snow fall is estimated to be 55 inches, with most snowfall occurring between October and May. July is the warmest month with an average high temperature of 84.6°F; December is the coldest with an average of 18.2°F. There are approximately 95 frost-free days at the site. Prevailing winds are from the southwest, averaging six miles per hour (mph). However, local relief influences air flow in the project area (SRK, 1990, and Newmont Services, 1987b).

5.1.3.2 Geology

Sediment-hosted gold of the Carlin trend is characterized by gold in the micron or less size range deposited in carbonaceous, thin-bedded silty limestones or limy siltstones. The suite of elements usually includes arsenic, antimony, mercury, thallium, and molybdenum. Barite is a common gangue mineral. Silicification in the form of jasperoid is used as a major indicator during exploration. According to the environmental assessment, rocks in the project area are composed of the Upper Devonian and Lower Mississippian age sediments (345 million years before present). Most of the site lies on Chainman Shale (Lower Mississippian) and, to a lesser degree, the Webb Formation (Lower Mississippian), and the Devil's Gate Limestone (Upper Devonian) . The Chainman Shale is composed of a variety of rock types including: grey to black shale, quartz and chert-rich sandstone, conglomerate lenses, thin limestone, calcareous sandstone beds, and pebbly mudstone. The Webb Formation consists of grey clay-rich siltstones and shales with interbedded sandstone. The Chainman Shale and Webb Formation unconformably overlie part of the Devil's Gate Limestone, characterized by medium to thick-bedded light to dark grey limestone. This is the material now being encountered at the base of the pit on the east end (see Figure 5-3

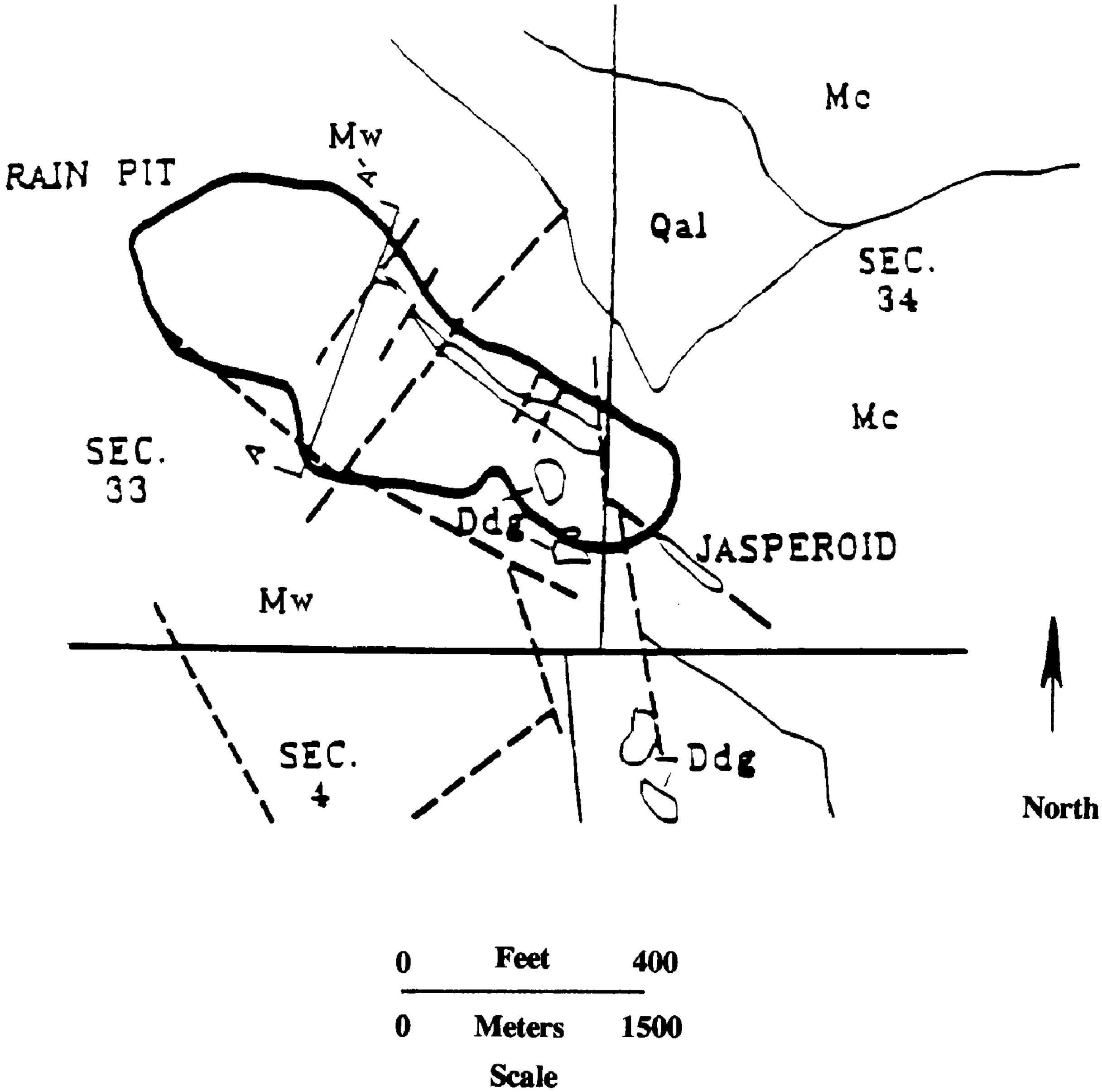


Figure 5-3. Pit Geology

(Source: SRK 1990)

) (Bonham, 1988; Newmont Services, 1987b; and SRK, 1990).

Structural control that led to the deposition of precious and other metals at the Rain site is similar to the processes found throughout the Carlin trend. A high angle reverse fault crosses the Rain pit on roughly a northwest strike. The fault is traceable for 1,800 feet along the surface and is up to 200 feet wide. It is this fault that is believed to be the paleo-conduit for hydrothermal fluids to migrate toward the surface. The Webb Formation hosts the minerals deposited by these migrating fluids. Joints in the Webb Formation intersect the fault and are partially responsible for the enrichment of the ore zone. Silica, gold, silver, mercury, arsenic, and a host of other elements filled voids and replaced material leached by the migrating acidic solutions. Gold occurs predominantly as micron-size particles disseminated in the host rock matrix. Rocks of the Webb formation near the surface are oxidized; consequently, the pyrite has been converted to hematite and/or limonite indicated by liesegang banding. Below the oxidized zone, rocks of the Webb Formation contain abundant carbon and pyrite. Most of the gold associated with the Rain ore zone is located near the Rain fault in oxidized and hematite-stained mudstones and siltstones of the Webb Formation. The vertical extent of gold mineralization ranges from the surface down to the unconformable contact with the Devil's Gate

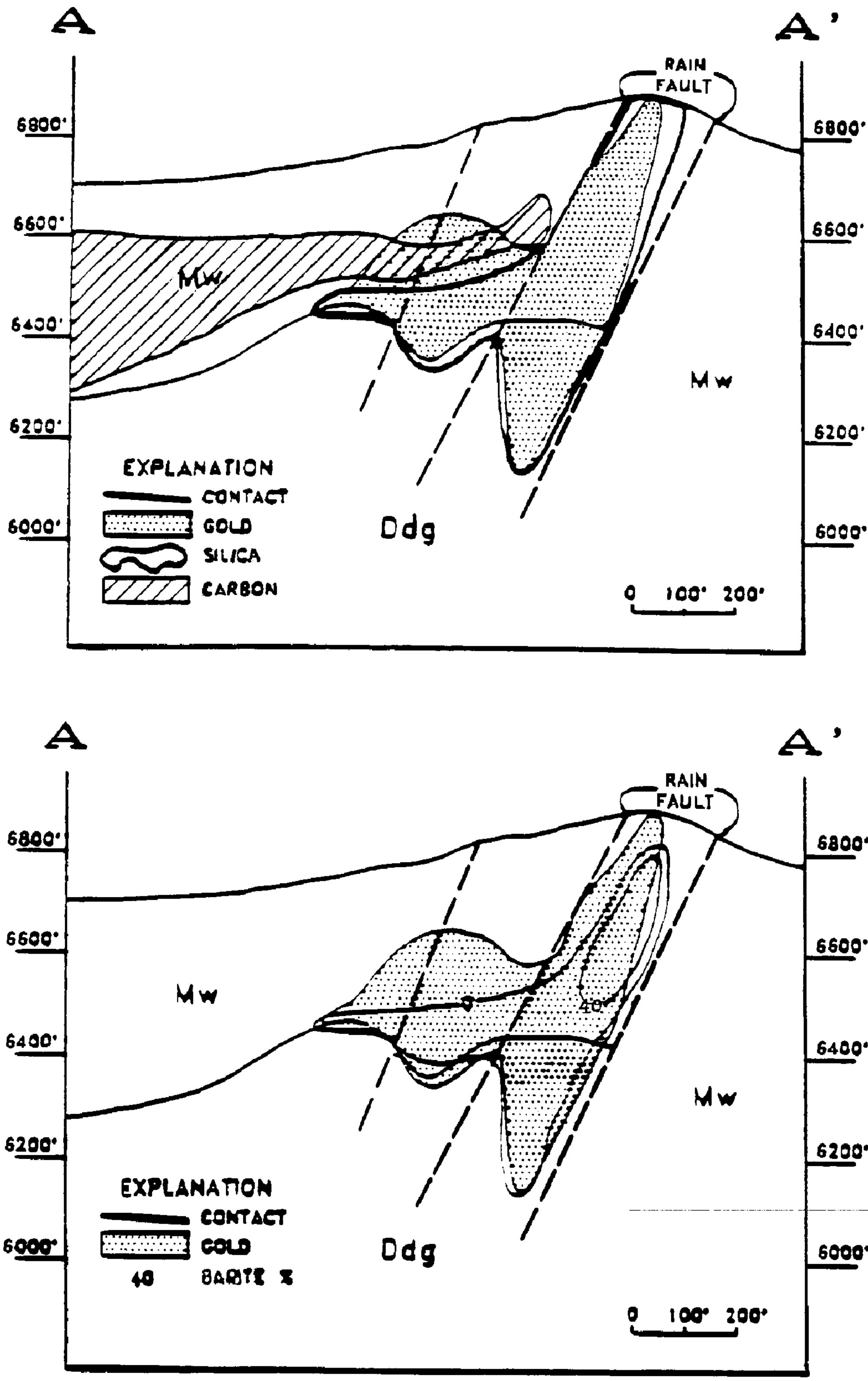


Figure 5-4. Cross Section of Rain Pit, Section 1800SE

(Source: SRK 1990)

limestone. Minor faults that intersect the main fault, possibly in more permeable material, allowed the fluids to migrate southwest of the main fault and therefore expanded the ore zone. Figure 5-4 shows a cross-section of the Rain pit (A - A') identified in Figure 5-3 (SRK, 1990).Six types of mineralization are recognized at the Rain mine: siliceous, siliceous/baritic, baritic, carbonaceous, argillaceous, and calcareous. Siliceous rocks contain greater than 40 percent quartz and less than 30 percent barite. Siliceous/baritic rocks contain 30 to 40 percent barite. Baritic rocks contain greater than 40 percent barite. Carbonaceous rocks contain high (unspecified) total organic carbon and greater than 0.5 percent pyrite (Figure 5-4). Argillaceous rocks have a clay content greater than 40 percent. Calcareous rocks are mostly carbonates, composed of calcite (SRK, 1990).

Most of the ore-grade material is taken from the oxidized sediments of the Webb Formation, proximal to the Rain fault. Ore taken from this area contains siliceous, siliceous/baritic, baritic, and argillaceous mineralization. Gold concentrations of this material range from 0.01 to 0.150 ounces of gold per ton of rock. It is expected that the carbonaceous material contains gold values as indicated by Figure 5-4 (SRK, 1990). According to Newmont, sulfide-bearing rock does not contain gold in sufficient quantity to be economically recoverable.

Of the 62.5 million tons of waste rock expected to be generated by the mine, 77.8 percent is expected to be mostly oxidized mixed sedimentary material of the Webb Formation (some of which will contain sulfide mineralization); 15.4 percent is expected to be carbonaceous and potentially sulfidic; 4.3 percent is expected to be limestone of the Devil's Gate Formation; and 2.5 percent will be alluvium from surface deposits (SRK, 1990).

5.1.3.3 Hydrology

The Rain facility sits on the drainage divide separating two basins. Seasonal surface water in the valley where the pit, mill facility, and tailings impoundment are located drains to the west into the ephemeral headwater drainage of Ferdelford Creek. Ferdelford Creek becomes a perennial stream four miles below the facility, and it runs for ten miles before entering Pine Creek. From this point, Pine Creek flows northwest and joins the Humboldt River six miles further downstream. Surface water on the north side of the saddle between the two peaks, where the waste rock dump is located, drains predominantly eastward in an ephemeral drainage toward Dixie Flats. Emigrant Springs (elevation 6,340 feet; about 900 feet from the toe of the waste rock dump) feeds the headwaters of this drainage, which joins Dixie Creek. Dixie Creek, a perennial stream, flows six miles north to join the South Fork of the Humboldt River. The site visit team also observed standing water immediately below (10 to 20 feet) the toe of the waste rock dump that appeared to be a spring but may have been part of the acid mine drainage collection system.

Baseline data that predate the Rain facility showed that waters of both Ferdelford and Dixie Creek have high pH, bicarbonate concentration, total dissolved solids, and conductivity. According to the environmental assessment, sulfate concentrations in Ferdelford Creek were three to four times higher than Dixie Creek, but decreased at lower elevation. Metals were generally low in Ferdelford Creek with the occasional exception of iron, aluminum, and arsenic. Arsenic, iron, and manganese were present in most samples taken from Dixie Creek (Newmont Services, 1987b).

Ground-water resources at and near the site have been described as limited. Shallow, perched water exists and discharges as perennial or ephemeral springs, such as Emigrant Spring. These discharges occur where alluvial material encounter impervious clays or silts. The shallow ground water is apparently recharged by local precipitation and snow melt and is not considered to be connected to the regional ground water. Deeper ground-water sources exist 350 feet or more below the surface and have been found to produce limited water volumes [maximum of 80 gallons per minute (gpm)]. Current mining in the pit has reached a depth of 460 feet below grade, to an elevation of 6,440 feet asl. Exploration drilling has encountered limited quantities of perched ground water between 6,400 and 6,300 feet. Newmont reports that the actual ground water elevation is between 6,100 and 6,160 feet and the projected pit bottom is 6,240 to 6,220 feet; thus, the final pit bottom should be about 100 feet above ground water. Because of the limited access to ground water, the Rain operation draws its water from wells (100 gpm annual average) in Dixie Flats and pumps it six miles to the mill (SRK, 1990).

5.2 FACILITY OPERATIONS

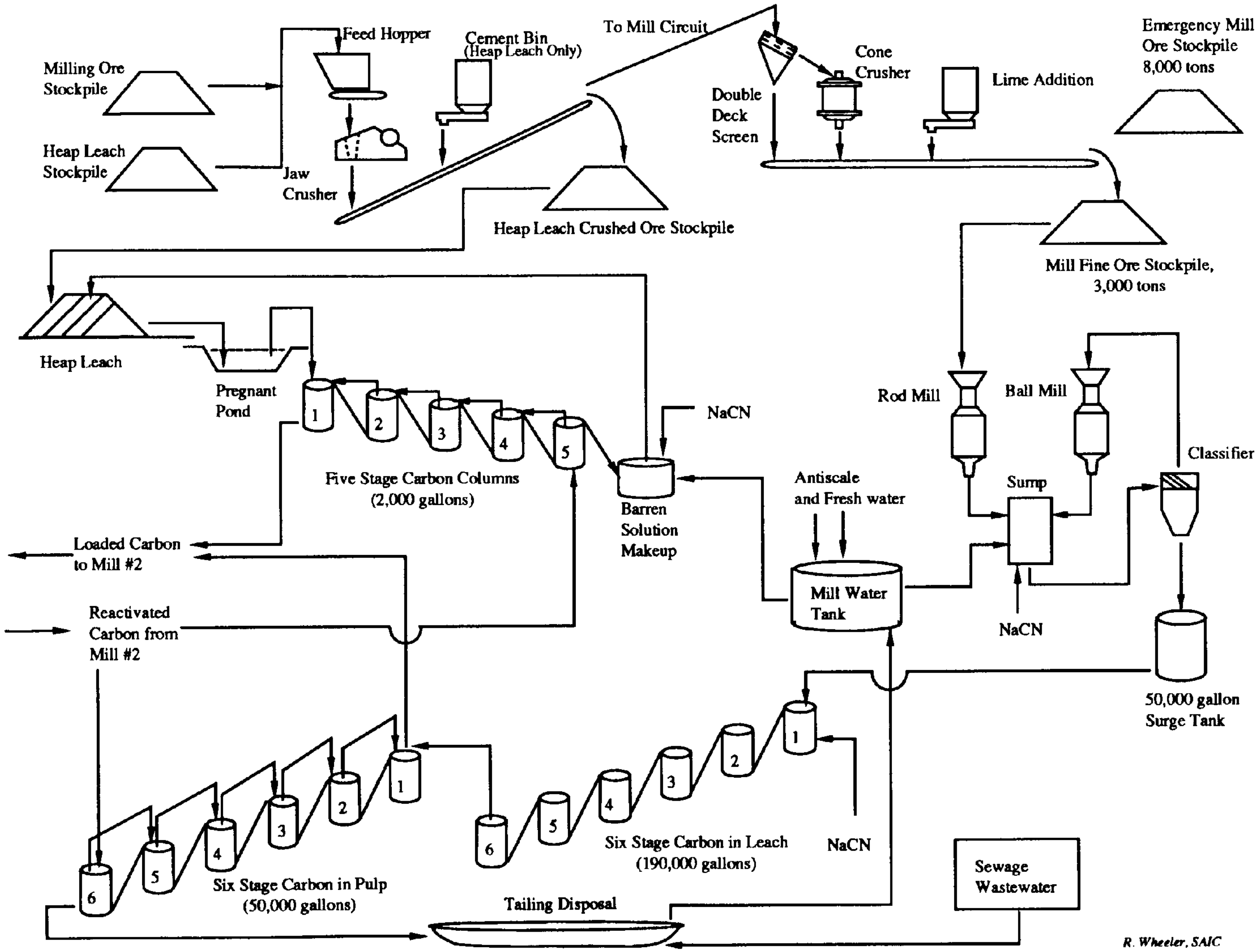
The Rain mine and mill were built between 1987 and 1988. Construction of the tailings dam began in October of 1987. Construction of the crusher foundation, leach pad, access road, and the solution handling system, carbon circuits, and water supply system was completed in April of 1988. According to the FEA, a work force from approximately 40 to as many as 150 people was estimated to be needed during construction, and 132 during normal operations. At the time of the site visit, 160 people were employed at the facility. The first gold production began on July 2, 1988 (Newmont Services, 1987b).

A Newmont Exploration Limited team is examining deposits west and east of the current pit in search of additional reserves. Ore resources in the immediate facility area (e.g., below the leach pad and under Rain peak) and on adjacent land may add to existing reserves and extend the life of the mine and mill. During the site visit, Newmont personnel noted the possibility of future underground mining to extract ore reserves below Rain Peak.

Several changes to the facility design described in the environmental assessment have occurred since the Rain facility began operation. The estimate of the volume of waste rock to be removed from the pit has increased from 37.5 to 62.5 million tons (Newmont Services, 1987b; and SRK, 1990). Original plans showed beneficiation continuing through electrowinning, at which point the steel wool cathode containing the gold would be sent to Newmont's Gold Quarry facility for refining (FEA, 1987). The primary operational difference between design plans in the environmental assessment and the "as built" facility is that beneficiation at the Rain facility ends when the carbon is loaded with gold. The loaded carbon is transported in a specially designed truck to the AARL/ZADRA facility at Gold Quarry (north of Carlin) for further beneficiation.

The total area of disturbance resulting from construction of the mine and mill is approximately 627 acres; widening of the existing Ridge Road for access disturbed a total of 43 acres. In early 1990, the estimate of the volume of material to be removed from the pit was 80.2 million tons (Knight Piesold, 1990). Of this, 6.7 million tons was considered to be mill grade ore, 11 million tons to be heap leach ore. Based on these figures the stripping ratio was about 3.55:1 (3.55 tons of waste rock must be removed to recover one ton of ore). At the time of the site visit, the stripping ratio was reported to be slightly lower, about 3.44:1.

Annual production of ore through the mill and leach pad is approximately 1.84 million tons. Roughly one million tons are heap leached, and the mill processes about 0.84 million tons annually. Ore grades for heap leaching are 0.01 to 0.05 ounces of gold per ton of ore. Mill grade material has a gold concentration of more than 0.05 ounces of gold per ton of ore. In 1988, the Rain facility produced approximately 115,000 ounces of gold. Heap leaching accounted for 13,100 ounces, while the mill produced 101,500 ounces. Material containing less than 0.01 ounces of gold per ton of rock is considered waste and disposed of in the waste rock dump. Individual flow charts showing flows of ore and solution at the Rain mine, mill, heap leach, and tailings process, were provided by Newmont after the site visit and are presented in Appendix 5-A (Newmont Gold Company, 1991b). A detailed description and flow chart (Figure 5-5



Milling Ore Stockpile
Heap Leach Stockpile
Feed Hopper
Jaw Crusher
Cement Bin (Heap Leach Only)
To Mill Circuit
Double Deck Screen
Cone Crusher
Lime Addition
Emergency Mill Ore Stockpile 8,000 tons
Heap Leach Crushed Ore Stockpile
Mill Fine Ore Stockpile, 3,000 tons
Heap Leach
Pregnant Pond
1
2
3
4
5
Five Stage Carbon Columns (2,000 gallons)
Barren Solution Makeup
NaCN
Rod Mill
Ball Mill
Classifier
Sump
Antiscale and Fresh water
Mill Water Tank
NaCN
Loaded Carbon to Mill #2
Reactivated Carbon from Mill #2
50,000 gallon Surge Tank
6
Six Stage Carbon in Pulp (50,000 gallons)
Six Stage Carbon in Leach (190,000 gallons)
NaCN
Sewage Wastewater
Tailing Disposal
R. Wheeler, SAIC

of the Rain operation is provided below.

During the visit, EPA reviewed Newmont's storage and handling methods for materials onsite. Support materials such as lubricating and hydraulic oils, truck fuel, and water are stored in tanks onsite; dry goods such as cyanide, cement, and lime are stored in large bins or bags, depending on the material. There is a 500-gallon tank for emergency generator fuel, a 30,000-gallon tank for truck fuel, a 6,000- gallon hydraulic oil storage tank, a 10,000-gallon waste oil tank, and a 6,000-gallon antifreeze tank. There are no underground storage tanks onsite. Sewage is piped to a treatment lagoon below the mill facility; effluent enters the tailings pipeline at about one gpm. Cyanide briquettes are stored in bins in a fenced area before use in the mill. Cement and lime are stored in 60- and 45-ton bins, respectively, in the crushing circuit. Drums of surfactants, antiscalant bags, and other goods are located near the points of use onsite. Magnesium chloride solution is stored in a tank where it is mixed with water and applied to the access road and other areas to control dust. Ammonium nitrate and fuel oil used during blasting is stored near the waste rock dump (away from most activity) and mixed onsite as needed.

Three wells located east of the facility in Dixie Flats can provide up to 1,200 gpm of fresh water. The water is piped 5.93 miles to the mill site in a 14-inch iron pipe buried four feet below ground. Two booster stations are used to pump the water upslope to the mill site. Two water tanks on the hill above the mill buildings store fresh water for the facility. A 15,000-gallon booster tank feeds a 200,000-gallon process, potable, and fire water tank. Newmont estimates that actual water consumption averages about 100 gpm on an annual basis; during dry months, consumption may reach 600 gpm.

5.2.1 Mining Operations

An open pit mine is used to remove ore and waste rock at Rain. The bottom of the pit is at 6,440 feet above sea level and is expected to reach 6,240 feet. The top of the pit is approximately 300 feet wide and 800 feet across and covers about 100 acres of the original ground surface. The pit is oriented northwest to southeast in alignment with the Rain fault. Access is by ramps entering from the east side; the pit is closed on the north, west, and south sides. The highwall on the west side rises approximately 600 feet from the bottom of the pit.

As the pit is extended downward, working benches are used to access the rock surface for drilling and blasting. Separate safety benches are left in the excavated wall to provide a catchment for localized pit slope failures. The pit is excavated in 20-foot working benches. Prior to blasting, drill hole cuttings (dry) are sampled for assaying and ore grading. The grade determines whether material is waste rock, leach ore, or mill ore. Visual observation determines if waste rock is sulfidic and must be handled separately. (Newmont reports it has undertaken a large-scale testing program to correlate visual classification of waste rock with the results of actual laboratory tests. As noted in section 5.3.2, Newmont samples waste rock for various parameters and for acid generation potential on a quarterly basis.)

After blasting, ore is loaded by front end loaders into 85- and 100-ton haul trucks and transported to either the waste rock dump or leach and mill ore stockpiles, as appropriate. As of 1990, estimates were that during the life of the mine, 80.2 million tons of rock would be removed from the pit. Of this, 6.7 million tons were projected to be mill grade, 11 million tons leach grade ore, and the balance of 62.5 million tons waste rock.

According to information presented during the site visit, an average of 35,000 tons of material is being removed from the mine each day. Of this, 5,500 tons is ore grade, 29,500 tons is waste. This rate may reach 7,000 and 40,000 tons per day, respectively (Newmont Gold Company, 1990d, 1991b). Ore material is separated based on grade and carried by 100-ton haul trucks to the leach or mill ore stockpiles. Of the 5,500 tons of ore mined each day, 3,150 tons is leach grade and 2,350 is mill grade. Waste rock removed from the pit is transported by 100-ton Wabco haul trucks to the waste rock dump for disposal. Mineral characteristics of the rock and disposal methods are discussed in Section 5.3.

The Rain facility employs unlined ore stockpiles. The stockpile for leach ore is referred to as the "primary" stockpile and typically contains about 250,000 tons; the mill ore stockpile is referred to as the "secondary" stockpile and typically contains about 50,000 tons. In some instances, leach ore may be carried directly from the pit or stockpile to the leach pad and not be sent through the jaw crusher. This material is referred to as run-of-mine ore. However, most of the leach ore is carried by truck to a stockpile located near the jaw crusher. Similarly, mill grade ore is carried to a stockpile adjacent to the leach ore stock. These piles near the crusher typically contain 30,000 tons of each ore, separated by a line of posts and old truck tires.

Prior to crushing, a front end loader selects mill or leach grade ore from the stockpiles, based on mill capacity and demand at the time. The primary jaw crusher is 36 by 48 inches, and can process 450 tons per hour to less than 6 inches in diameter. A slewing and luffing conveyor system is pivoted, depending on which ore type is being crushed. Mill grade ore is conveyed to the secondary crushing circuit; leach ore is fed from the conveyor to a pile located between the primary and secondary crushers.

Leach grade ore receives only primary crushing and agglomeration before being transported to the heap. Following crushing, about eight pounds of cement is added per ton of ore from a 60-ton storage bin to agglomerate the fine particles. Water is added through V-Jet sprays at a rate of about 10 gpm to begin cement agglomeration. Leach grade ore is stockpiled on the ground by the conveyor, away from subsequent crushing facilities, to be trucked to the heap. The volume in this stockpile varies.

When mill grade ore is crushed, the slewing and luffing conveyor is pivoted to a position above an ore bin that feeds the secondary crushing system. This system consists of a 5-by-16-foot Simplicity double deck screen and a 5.5-foot Nordberg cone crusher. Oversized material (greater than 3/4 inches) from the screen is passed to the crusher, while undersized ore falls directly to a conveyor belt. The cone crusher reduces the particle size of ore received from the primary crusher to less than 3/4 inches. The product from the screen and cone crusher is transported by conveyor to the 3,000-ton mill stockpile prior to entering the mill on a second conveyor. An emergency mill stockpile of 8,000 tons is maintained in the event the crusher circuit fails. To control pH, pebble lime is metered onto the mill feed conveyer from a 45-ton capacity bin at an average rate of 1.7 pounds per ton.

Dust generated while handling the ore during crushing and transport is controlled by fogging type spray nozzles. Water and a sodium and calcium stearate surfactant (at a total application rate of 600 cc/minute, of which 20 cc are surfactant) are applied where crushing and grinding take place, when cement or lime are added to the ore on the conveyor belt, and where ore is transferred from one conveyor belt to another. V-Jet sprays, as noted above, are used for agglomeration. Baghouses are used to capture dust emitted during loading of the cement and lime storage bins; baghouse material is recycled back to the respective bins.

5.2.2 Mill Operation

Ore is fed by conveyor into an Allis-Chalmers 400-horsepower rod mill at an average rate of 96 tons per hour, along with sufficient mill solution to make a slurry of 68 percent solids. Mill water supply is made up in a tank by adding reclaim water from the tailings impoundment, water treatments such as antiscalants (24 cc/min of polymaleic acid), and fresh water (as necessary), and is distributed throughout the mill. Newmont is required to sample reclaim water on a quarterly basis, and mill water supply is also sampled; recent analytical results for reclaim and mill water are presented in Tables 5-1

Table 5-1. Analysis of Reclaim Water Returned to the Mill from the Tailings Impoundment

Sample: Reclaim Water	Sample Date (values in ppm)			
Parameter	**12-6-90**	**3-4-91**	**4-30-91**	**7-29-91**
pH	9.9	10.0	9.5	8.8
TDS	830	660	830	1600
WAD Cyanide	40.0	14.0	5.8	9.6
Antimony	<0.05	<0.05	<0.05	<0.05
Arsenic	0.19	0.26	0.23	0.14
Barium	0.47	7.4	0.080	0.008
Cadmium	0.009	0.020	<0.005	0.005
Calcium	140	120	140	260
Chloride	69	96	110	260
Chromium	<0.005	0.009	<0.005	0.011
Copper	5.5	4.3	3.7	6.3
Fluoride	5.2	5.2	5.3	5.7
Iron	0.35	2.40	0.28	0.20
Lead	<0.005	<0.005	<0.005	<0.005
Magnesium	0.95	2.8	3.4	2.6
Manganese	<0.005	0.026	<0.005	0.012
Mercury	0.32	0.30	0.33	0.29
Molybdenum	<0.082	0.066	0.065	0.12
Nitrate	17.0	14.0	14.0	24.0
Selenium	0.27	0.08	0.05	0.12
Silver	<0.005	<0.005	<0.005	<0.005
Sodium	140	99	130	250
Sulfate	310	250	310	700
Thallium	<0.005	<0.005	<0.1	<0.1
Zinc	0.99	1.20	0.27	0.21

Source: Data aggregated from quarterly reports submitted by Newmont to NDEQ as required by permit.

and 5-2, respectively.

Table 5-2. Analysis of Mill Water

Sample: Mill Water Supply	**Sample Date (values in ppm)**
Parameter	**12-30-90**
pH (s.u.)	8.1
TDS	210
WAD Cyanide	<0.005
Arsenic	<0.005
Barium	0.17
Bicarbonate	170
Cadmium	<0.005
Calcium	33.0
Chloride	12.0
Chromium	<0.005
Copper	<0.005
Fluoride	<0.5
Lead	<0.005
Magnesium	<0.01
Mercury	<0.0001
Nitrate + Nitrite	0.14
Selenium	<0.005
Silver	<0.005
Sodium	24.0
Sulfate	16
Zinc	<0.005

Source: Data aggregated from information on file with NDEQ.

Mill solution is circulated at approximately 600 gpm, most of which is recycled from the tailings impoundment (Table 5-1). Fresh water makeup averages 30 to 50 gpm, with maximum fresh water demand (up to 550 gpm) occurring in late summer. The rod mill discharges into the cyclone feed sump, where cyanide is added at an average rate of 0.28 (maximum rate is 0.50) pounds per ton of ore. The cyanide solution is made up by adding 50 pounds of caustic to each 3,000 pounds of sodium cyanide. Caustic is added to maintain the pH of the working solution above 10. At 2,000 gallons per batch, a 3-day capacity of cyanide solution is maintained onsite (approximately 6,000 $\pm$ 2,000 gallons). The cyanide solution is transferred from a mixing tank, through the plant, to the cyclone feed sump in schedule 80 steel pipe (see Appendix 5-B).A pump transfers the slurry from the sump to four cyclone classifiers. Cyclone underflow is transferred to secondary grinding to further reduce the particle size. An Allis-Chalmers 800-horsepower ball mill is used to reduce coarse particles and discharges to the cyclone feed sump pump for transfer back to the classifiers. Cyclone overflow passes a trash screen to remove wood and other coarse material. These screens generate approximately one ton of trash per week, and the material collected is hauled to the leach pad. Ore output from the classifier is 70 percent less than 200 mesh (0.003 inches, or 74 microns) and is transferred to a 50,000-gallon surge tank before entering a series of six leach tanks.

Each of the leach tanks has a capacity of 190,000 gallons (see Figure 5-5). A low concrete retaining wall surrounds the surge and leach tanks; Newmont staff indicate that it would contain at least 190,000 gallons (the volume of one of the leach tanks). Cyanide may be added in the leach tanks as needed, but this is not typically required at Rain. Ore slurry from the surge tank is transferred by pump to the first leach tank. An agitator is used in each leach tank to keep the ore in suspension. Air is injected to supply oxygen necessary for the cyanide to dissolve the gold. The slurry flows continuously by gravity through tanks 1 to 6 (residence time in the leach tanks was not determined). Both the path and flow rate are controlled by gate valves at the top of the tanks. As the slurry moves through tanks 1 to 6, the barren cyanide solution leaches gold, silver, and some mercury from the ore, forming a pregnant solution in the presence of the spent or leached ore. The total residence time in the six leach tanks is approximately 36 hours.

From the leach tanks, the slurry is transferred to a series of six Carbon-In-Pulp (CIP) tanks (see Figure 5-5). Each tank has a 50,000-gallon capacity; an agitator is used to keep the slurry in suspension, and air is injected to promote adsorption of the metal-cyanide complex onto activated carbon. The pregnant solution and spent ore enter tank number 1 and move by gravity toward tank number 6. Activated carbon (6 by 12 mesh; 1.4 to 3.6 millimeters) is added to tank number 6 at a rate of 2.2 tons per day and moves sequentially through tanks 5 to 1 every 24 hours. The carbon slurry flows by gravity across a screen that traps the coarse grain carbon; from there, carbon is advanced by pump to the next tank, counter-current to the slurry flow. With each succeeding tank (from 6 to 1) the carbon adsorbs more of the gold. By contrast, less gold is in solution as the ore slurry moves through succeeding tanks (from 1 to 6).

Loaded carbon exiting tank 1 contains approximately 250 ounces of gold per ton of carbon and lesser quantities of silver and mercury. Carbon from the CIP circuit is washed over screens to remove fine carbon particles. About 2.2 tons per day of coarser particles are pumped to a 10-ton holding tank prior to shipment by truck to Newmont's Gold Quarry facility, where the gold is recovered from the carbon and the carbon reactivated. After reactivation, the carbon is returned to the Rain facility. Fine carbon particles that pass through the screen are collected in drums until sufficient quantities accumulate; about 2.6 tons of fine carbon product is generated each month. This is either shipped to the Gold Quarry facility or to a third party to recover the metal values.

Tailings composed of mill solution, spent ore, and small quantities of carbon that pass the screens in the CIP tanks report to the tailings impoundment via a 12-inch diameter HDPE pipe 2,400 yards long. Tailings exit the mill by gravity flow at approximately 800 gpm, containing 35 to 40 percent solids. The solution has a pH of approximately 10, and weak acid dissociable cyanide of approximately 30 parts per million (ppm) (Newmont Gold Company, Quarterly Monitoring Reports). The facility is required to monitor tailings water quarterly from a spigot in the pipeline. Results of four quarters between 1990 and 1991 are shown in Table 5-3

Table 5-3. Analysis of Tailings Water

Sample: Tailings Water	Sample Date (values in ppm)			
Parameter	**12-6-90**	**3-4-91**	**4-30-91**	**7-29-91**
pH (s.u.)	9.9	10.6	10.4	10.4
TDS	590	440	700	1500
WAD Cyanide	35	25	19	20
Antimony	<0.05	<0.06	0.06	0.17
Arsenic	0.30	0.33	0.11	38.00
Barium	0.14	0.42	0.27	2.50
Cadmium	0.013	0.011	0.006	0.150
Calcium	90	120	140	730
Chloride	53	98	110	280
Chromium	<0.005	<0.005	<0.005	2.300
Copper	4.3	4.4	3.3	10.0
Fluoride	3.8	0.9	4.9	1.6
Iron	0.51	0.15	0.22	1300
Lead	<0.005	<0.005	<0.005	<0.005
Magnesium	0.31	0.12	0.10	32.00
Manganese	<0.005	<0.005	<0.005	11.00
Mercury	0.079	0.340	0.530	3.400
Molybdenum	0.070	0.084	0.070	<0.05
Nitrate	12.0	16.0	16.0	26.0
Selenium	0.250	0.094	0.082	0.140
Silver	<0.005	<0.005	<0.005	0.005
Sodium	90	89	130	260
Sulfate	250	240	120	120
Thallium	<0.005	<0.005	<0.005	3.2
Zinc	0.74	0.41	0.29	0.48

Source: Data aggregated from quarterly reports submitted by Newmont to NDEQ as required by permit.

On August 19, 1988, the tailings line became plugged, causing the mill tailings to leak out of the vents in the line. According to Newmont, most of the leaking vents were within the limits of the tailings impoundment. Newmont estimated that 12.46 pounds of cyanide were released in a 10.4 pH solution. Both the Nevada Department of Emergency Management (Incident No. 81908C) and the National Response Center (Incident No. 11505) were notified. Cleanup consisted of scooping up the material spilled outside the tailings impoundment and placing it within the limits of the impoundment. To prevent the problem in the future, the tailings line was repositioned so that all vents would spill into the limit of the tailings impoundment (Newmont Gold Company, 1988d).

In the event of a spill in the mill, floor drains in the concrete floor run to sumps in the grinding and carbon handling areas. Fresh water may be used to flush material into the sumps for return to the appropriate mill circuit. The surge, leach, and CIP tanks are located outside the mill building and are surrounded by a low concrete retaining wall.

Blowers in the mill building exchange the air to avoid any buildup of cyanide gas. In addition, workers must wear fully self-contained breathing apparatus for protection from fumes during the mixing process. Alarms are located throughout the building and are activated if hydrogen cyanide levels exceed five ppm. As reported during the site visit, this alarm has sounded one time, in response to spilling one or two cyanide briquets on the floor while adding sodium cyanide to the mixing tank.

5.2.3 Heap Leach

The Rain heap leach covers an area of approximately 71 acres in the valley above the tailings impoundment (Newmont Gold Company, 1990d). Prior to constructing the pad, a French drain system was installed to remove soil moisture seepage collected from the natural drainage system. West and east drains were installed. These drains also collect any fugitive process fluids from the pad. Fluid collected by the drains is transported to the tailings impoundment in a High Density Polyethylene (HDPE) pipe (size unknown). According to Newmont, the west French drain discharges an average of 0.88 gpm (maximum of 10.2 gpm), and the east French drain discharges an average of 0.29 gpm (maximum of 4.2 gpm) (Newmont Gold Company, 1991b). Discharge from these drains is reported in Quarterly Monitoring Reports; data for the last three quarters is presented in Section 5.4.1.3.The pad overlies the French drain system; it consists of 12 inches of compacted native soil covered by an 80-mil HDPE synthetic liner; the synthetic liner is protected by an 18-inch layer of gravel. The gravel is drained by a network of perforated collection pipes that collect the gold-laden leachate (pregnant solution) and minimize the buildup of hydraulic head (NDEP, 1988a; Newmont Gold Company, 1990d).

Ore is delivered to the pad in 100-ton haul trucks. The trucks deliver crushed ore from the leach ore stockpile near the mill at an average rate of 3,150 (9,500 maximum) dry tons per day. Run-of-mine ore is delivered directly from the pit at an average rate of 555 (6,000 maximum) dry tons per day. As designed, the pad is divided into 30 cells, each covering approximately 100,000 square feet. The pad is constructed in 20-foot lifts. Two lifts have been constructed. Ultimately, a total of 10 lifts will bring the height of the heap to 200 feet. Leach ore is currently placed on the pad at a rate of about one million tons per year. Total capacity of the heap is 11 million tons.

Barren solution contains a working concentration of about 50 ppm cyanide. An average of 214 pounds of sodium cyanide is added to the barren solution per day to maintain a working concentration, but peak demands may be as high as 400 pounds per day. Sodium hydroxide is added to maintain a solution pH of about 10.0. The average rate of addition is 437 pounds per day (maximum of 1,000 pounds). Antiscalant is added to both the barren and pregnant solution at 14 cc per minute to control scale build-up. Make-up water is added to the solution at a rate ranging from less than one gpm in April and May to as high as 100 gpm during the hot, dry months of July and August. A chemical analysis of the barren solution following makeup is presented in Table 5-4

Table 5-4. Analysis of Barren Solution

Sample: Barren Solution	Sample Date (values in ppm)			
Parameter	**12-6-90**	**3-4-91**	**4-30-91**	**7-29-91**
pH (s.u.)	9.4	10.3	10.1	10.1
TDS	930	660	930	1900
WAD Cyanide	34.0	24.0	34.0	66.0
Antimony	<0.050	<0.005	<0.050	<0.050
Arsenic	0.21	0.67	0.52	0.59
Barium	0.09	0.07	0.07	<0.05
Cadmium	0.018	0.019	0.016	0.014
Calcium	190	150	150	160
Chloride	120	130	110	170
Chromium	0.056	0.100	0.054	0.019
Copper	6.2	6.4	6.2	9.1
Fluoride	1.2	1.9	1.5	1.4
Iron	0.55	0.05	0.11	0.47
Lead	<0.005	<0.005	<0.005	<0.005
Magnesium	1.70	0.33	1.20	1.80
Manganese	0.038	<0.005	<0.005	0.027
Mercury	4.6	3.6	1.7	6.1
Molybdenum	0.100	0.320	0.170	0.082
Nitrate	56	37	38	43
Selenium	0.120	0.090	0.061	0.080
Silver	<0.005	<0.005	<0.005	<0.005
Sodium	120.0	71.0	130.0	430.0
Sulfate	260.0	170.0	250.0	860.0
Thallium	<0.01	<0.005	<0.01	<0.10
Zinc	0.35	0.13	0.23	0.28

Source: Data aggregated from quarterly reports submitted by Newmont to NDEQ as required by permit.

The solution is pumped to the heap at an average of 551 gpm, and applied at a rate of 0.006 gpm per square foot (Newmont Gold Company, 1991b). This rate is sufficient to leach approximately one cell at a time.

In warm months, the barren solution is applied using rotary sprinklers. During the site visit, some ponding was observed on a portion of the heap surface, and spray was felt on another portion of the heap, a short distance away from the cell being leached (according to the representative of the Nevada Department of Wildlife who participated in the site visit, such ponding has not resulted in any wildlife mortality at Rain). In winter, a drip system is used to prevent accumulation of ice on the surface of the heap. Lime is added directly to the top of the heap as needed to maintain the solution pH at or near 10. According to the environmental assessment (Newmont Services, 1987b), 10 percent of the solution applied to the heap was expected to be lost to evaporation and a smaller portion absorbed by the ore material.

Once applied to the heap, the barren cyanide solution dissolves the gold values. The solution, with increasing amounts of gold, percolates through the pile to the perforated pipe located above the liner. The pipes convey the pregnant solution to lined collection ditches that extend around three sides of the pad and connect to the pregnant solution pond. The pregnant pond is located at the base of the heap in the valley bottom above the tailings impoundment. The pond is designed to hold five million gallons of solution. It is double lined with a leachate detection and recovery system between the liners. The lower liner, of unspecified-grade HDPE, overlies 12 inches of compacted native clay. A geotextile material was installed above the lower liner to allow detection and, as necessary, collection of any fugitive pregnant solution escaping the 80-mil HDPE primary liner. In the event that solution is observed, a sump is used to pump liquid to the tailings impoundment. According to Newmont, the leak detection system recovers an average of 0.38 gallons per day (gpd) and a maximum of 15 gpd. If the pregnant pond overflows, solution enters a ditch lined with an 80-mil HDPE liner, which drains by gravity to the tailings impoundment. Solution concentrations and Newmont's management strategy are discussed in Rain's "Fluid Management Plan, Best Management Plan" (NDEP, 1988a; and Newmont Gold Company, 1991b).

As a requirement of their Water Pollution Control Permit, Newmont analyzes pregnant solution chemistry quarterly. In the past 4 quarters, pH values have ranged from 9.8 to 10.3; WAD cyanide from 19 to 53 ppm; sulfate from 180 to 880 ppm; and mercury from 3.9 to 6.9 ppm. Chemical analysis of the pregnant solution for this period is presented in Table 5-5

Table 5-5. Analysis of Pregnant Solution

Sample: Pregnant Solution	Sample Date (values in ppm)			
Parameter	**12-6-90**	**3-4-91**	**4-30-91**	**7-29-91**
pH (s.u.)	9.8	10.3	9.8	10.0
TDS	910	750	900	1800
WAD Cyanide	53.0	28.0	19.0	28.0
Antimony	<0.05	<0.05	<0.05	<0.05
Arsenic	0.22	0.65	0.52	0.56
Barium	0.09	<0.06	0.08	<0.05
Cadmium	0.017	0.019	0.016	0.017
Calcium	160	150	150	160
Chloride	110	130	80	160
Chromium	0.06	0.1	0.056	0.019
Copper	6.2	6.5	6.6	9.2
Fluoride	1.4	1.9	1.6	1.4
Iron	0.56	0.04	0.08	0.45
Lead	<0.005	<0.005	<0.005	<0.005
Magnesium	1.7	0.54	1.2	1.9
Manganese	0.041	<0.005	<0.005	0.027
Mercury	6.9	4.6	3.9	4.3
Molybdenum	0.1	0.32	0.17	0.079
Nitrate	50	38	37	19
Selenium	0.14	0.092	0.084	0.085
Silver	0.006	<0.005	<0.005	0.009
Sodium	95	92	110	400
Sulfate	220	180	240	880
Thallium	<0.01	<0.005	<0.01	<0.1
Zinc	0.36	0.13	0.23	0.28

Source: Data aggregated from quarterly reports submitted by Newmont to NDEQ as required by permit.

A pump transfers the pregnant solution to the Carbon-In-Column (CIC) circuit in the mill building at a rate of approximately 550 gpm. The Rain CIC circuit consists of five columns, each with a capacity of approximately 2,000 gallons. Pregnant solution enters column number 1 (see Figure 5-5). Fresh, activated carbon (6-by-12 mesh; 1.4 to 3.6 mm) enters column number 5 at an average of 0.4 tons per day (maximum 1.0) and is pumped sequentially through tanks 5 to 1. In the tanks, the solution flows by gravity across a carbon screen. The carbon collected on the screen is advanced by pump on an hourly basis to the next tank, counter-current to the solution flow. With each succeeding tank (from 5 to 1) the carbon adsorbs more of the gold. By contrast, less gold is in solution as the pregnant solution moves through succeeding tanks (from 1 to 5). Fully loaded carbon exits tank number 1 and is pumped to the 10-ton holding tank for transfer to the Gold Quarry facility. Barren solution exits tank number 5 and is returned to the barren solution make-up tank in the mill building, where cyanide, sodium hydroxide (to buffer the pH), and water are added prior to recycling it back to the heap.

The Rain operation does not use a barren solution pond in its fluid management system. All the solution resides in the process circuit, the heap, and the pregnant pond.

5.2.4 Facility Control Room

As part of the facility walkthrough, site visit participants viewed the mill control room as well as the equipment and vehicle maintenance building. The control room monitors and controls mill tonnage, slurry flow rates, solution chemistry, and various liquid levels in tanks throughout the mill building. An operator is on duty at all times to note changes and record conditions at scheduled intervals. Cyanide levels in the leach and mill circuits are determined by the operator every two hours by titration with silver nitrate; these values are averaged every 24 hours.

5.3 MATERIALS AND WASTE MANAGEMENT

For purposes of this discussion, materials management practices at the Rain facility are divided into process and waste management units. Process units are those that contain materials that are not considered wastes until after facility closure. Examples of process units (and process materials) are heap leach pads (and spent ore) and the open pit (and mine water that may reside in the pit). Waste units are those that contain materials that will undergo no further beneficiation. Examples of these include waste rock piles and the tailings impoundment.

Waste rock removed from the pit during mining is disposed in the waste rock dump. Mill tailings are disposed in the tailings impoundment. Tailings water is recycled to the mill or heap continuously until facility closure. Smaller volumes of other wastes generated onsite include sanitary sewage, waste oil, grease, used tires, and refuse.

5.3.1 Mine Pit and Heap Leach

According to Newmont, closure is tentatively scheduled for 1995. Mill activity will cease about one year before leaching ends. However, experience at the Newmont Gold Quarry facility indicates active leaching may continue for two to three years following the last addition of ore (Newmont Gold Company, 1990d).

The final depth of the Rain Pit may reach 6,240 feet asl. According to Newmont, it is not expected to extend below the water table, though perched aquifers may be encountered. Inflow to the pit by direct precipitation and ground water is not expected to cause ponding in the pit. In addition, Newmont will construct diversion ditches on the slope above the pit to limit surface water inflow (Newmont Gold Company, 1990d).

The mill leach circuit will stop operation when all mill grade ore is removed from the pit. The remaining mill solution will be combined with the leach circuit. The CIC circuit will continue to recover gold values until heap leaching stops as noted above. Newmont has not indicated what will be done with the mill facility in their Tentative Closure Plan (Newmont Gold Company, 1990d).

Section 5.2.3 above describes the construction of the heap leach and the quantities of spent ore (i.e., up to 11 million tons) that will remain on the pad at closure. At closure, the spent ore will be rinsed to meet State of Nevada regulations, which require that effluent rinse water have weak acid dissociable (WAD) cyanide levels below 0.2 mg/liter and a pH between 6 and 9. As currently planned, fresh water will be used to rinse the heap. The addition of calcium hypochlorite, ferric sulfide, hydrogen peroxide, or other chemicals may be required to detoxify the residual cyanide in the heap. A second rinse with the possible addition of acid may be required to lower the pH. Following the rinse cycle, the leaching solution will require disposal. Newmont is conducting test work on the best method to rinse the spent ore. According to the environmental assessment (Newmont Services, 1987b), the heaps will be covered with topsoil and revegetated. Newmont also is considering reclamation as a means to mitigate the concern for mobilization of contaminants by meteoric water. The premise is that infiltration will be eliminated by a soil and vegetation cover (Newmont Gold

Company, 1990d). As described in Section 5.4.1.2, Newmont is in the process of preparing a reclamation plan for submission to the State (Newmont Services, 1987b).

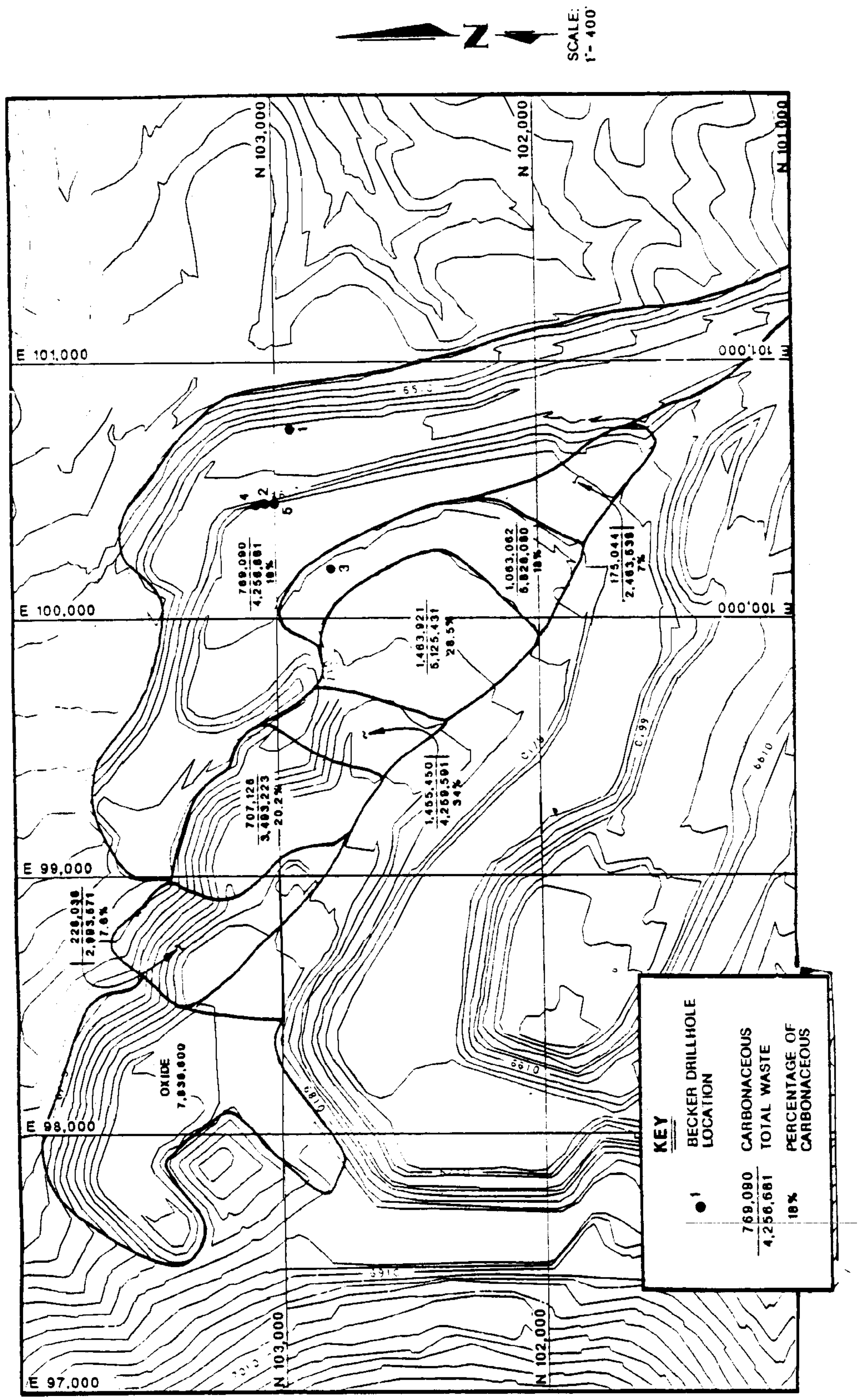
5.3.2 Waste Rock Dump

Currently, the waste rock dump covers 211 acres and is located north and east of the pit. Waste rock production from the pit averages 29,500 tons per day. Of this, 7,500 tons are sulfidic and 22,000 tons oxide. Newmont estimates that by mine closure in 1995, there will be 62.5 million tons of waste rock; of this, 77.8 percent is expected to be mostly oxidized mixed sedimentary material of the Webb Formation (some of which will contain sulfide mineralization), 15.4 percent will be carbonaceous and potentially sulfidic, 4.3 percent will be limestone of the Devil's Gate Formation, and 2.5 percent will be alluvium from surface deposits. Based on mining records prior to August 1990 and the expected future mining schedule, waste rock tonnage by type of rock is presented in Table 5-6. The distribution of carbonaceous versus total waste in the waste rock dump as of June 1990 is presented in Figure 5-6

Table 5-6. Projected Waste Rock Generation (Waste Tonnages X 1000)

Year	Total	Carbonaceous	Limestone	Other	Alluvium
to 8/90	34,768	5,187	222	29,049	310
8/90 to 12/90	6,630	815	---	5,389	426
1991	7,169	2,050	---	4,508	611
1992	6,352	969	645	4,521	217
1993	5,154	544	824	3,786	---
1994	2,180	38	823	1,319	---
1995	267	---	205	62	---
TOTAL	62,520	9,603	2,719	48,634	1,564

Source: SRK, 1990


N
SCALE:
1" - 400'
E 97,000
E 98,000
E 99,000
E 100,000
E 101,000
N 101,000
N 102,000
N 103,000
OXIDE
7,838,600
228,038
2,993,571
7.6%
707,128
3,493,223
20.2%
1,455,450
4,259,591
34%
1,463,921
5,125,431
28.5%
769,090
4,256,681
18%
1,063,062
5,828,080
18%
175,044
2,463,538
7%
KEY
1 BECKER DRILLHOLE LOCATION
769,090 CARBONACEOUS
4,256,681 TOTAL WASTE
18% PERCENTAGE OF CARBONACEOUS

(SRK, 1990; Newmont Gold Company, 1990d).

Prior to the spring of 1990, sulfide, oxide, and calcareous waste rock were disposed together. On May 8, 1990, acid drainage was observed flowing from the base of the waste rock dump and into the unnamed drainage above Emigrant Spring, toward Dixie Creek. Inspection of the drainage downstream of the dump revealed that approximately two miles of the channel contained a red-brown precipitate. Discharge to the drainage was estimated by Newmont to be 3 gpm. Surface-water samples were taken along 5 points in the drainage above and below Emigrant Springs in May, June, and July of 1990. They showed pH values ranging from 2.37 to 3.21 near the base of the waste rock at the discharge point, and from 6.5 to 8.64 about 4,000 feet downstream. Arsenic near the effluent point was 46 ppm in May and 1.5 ppm in July; at the distant sampling point, arsenic was 0.023 ppm in May and 0.005 ppm in July. Mercury near the discharge point was 0.19 ppm in May and 0.0019 ppm in July; at the distant sampling point, mercury was <0.0001 ppm in May and 0.0003 ppm in July (SRK, 1990). Results of the chemical analyses are presented in Appendix 5-B, Tables 5-14 through 5-19.

In response to the drainage, Newmont took the following actions. By May 9 (one day after the drainage was noted), a small pond was constructed to collect the flow from the dump. On May 11, an HDPE liner was installed in the pond. On May 18, Newmont constructed a cutoff trench across the channel downstream of the collection pond to collect subsurface solution. The trench was twenty feet deep and forty feet across and included a HDPE liner. Inflow to this trench was pumped to the collection pond and then trucked to the tailings impoundment for disposal (Newmont Gold Company, 1990b).

Newmont notified the Nevada Division of Environmental Protection (NDEP) of the situation on May 10, 1990.

Newmont's assessment of the acid drainage problem noted that it occurred during the snowmelt period of 1990 and cites two contributing factors for the occurrence of discharge. First, snow accumulation removed from other areas of the facility was disposed of on a localized area of the dump. The volume in the pile may have represented as much as 5 to 15 times the average snow pack. Second, the premining topography of the dump area collects and concentrates surface drainage from a watershed of about 35 acres. As the snow melted, it infiltrated the waste rock pile, oxidizing sulfur-bearing minerals and generating acid. The solution migrated along premining topography and discharged at the toe of the dump.

Long-term mitigation of the acid drainage problem was proposed by Newmont in the "Rain Project Solution Collection and Return System Design Report" (SRK, 1990). The State and BLM approved the plan and construction began in November of 1990 and was completed in March of 1991. The solution collection and return system consists of surface and subsurface water collection and recovery. Surface water is collected by a ditch and drains to a sump located at the toe of the waste rock pile. Drainage collected by the sump drains by gravity to a 200,000-gallon capacity, double-lined pond. Subsurface flow is recovered in an HDPE-lined trench and also drains to the double-lined pond. At the time of the site visit, discharge from the waste rock dump was estimated to be less than one gpm. Following the site visit, Newmont supplied data indicating that flows average 23.8 gpm with a maximum of 183 gpm (Newmont Gold Company, 1991b). In the event of a power failure, the pond has a capacity to retain in excess of 65 hours of inflow at the maximum projected flow. In addition, storm water from the surface of the waste rock dump and surrounding area is collected in a single-lined, 600,000-gallon pond located just below the double-lined pond. Solution from both ponds is pumped to the mill area and added to the tailings pipeline (SRK, 1990).

In addition to these engineering designs for acid drainage recovery, Newmont has changed its waste rock disposal practices for material with the potential to generate acid drainage. Of the final estimated volume of waste rock, approximately 15 percent (9.6 million tons) is expected to be carbonaceous and potentially sulfidic. More than one half of this was generated before the acid drainage problem developed in May of 1990. Prior to this, sulfide material was mixed with oxidized material or the limited quantity of calcarious material available to buffer any acidic solution generated. The sulfidic materials are fine to coarse grain sedimentary rocks extracted primarily from the Webb Formation.

Sulfidic waste rock is now being encapsulated within oxidized and/or calcareous waste rock that has either no net acid generating potential or some acid neutralizing potential. This is accomplished by placing a pervious layer of coarse oxidized waste rock on the native soil. On this, five feet of compacted oxidized ore is placed. Additional oxide ore is placed against the natural hillslope to act as a barrier. These layers act as barriers to water movement into and out of the sulfide waste rock. Following these steps, sulfidic waste rock is placed on, and in front of, the oxide ore. Several lifts are expected to be added to the sulfide waste pile. Haul trucks follow random routes during construction to compact the material, thereby reducing its permeability. Eventually, the front edge and top will be covered with 15 feet of oxidized material to complete the encapsulation.

As part of the revised Water Pollution Control Permit (see Section 5.4), Newmont reports quarterly on results of Meteoric Water Mobility testing and Waste Rock Analysis (see Appendix 5-E for NDEP guidance on this procedure). The meteoric mobility test is an extraction procedure. The extracted solution is analyzed for nitrate, phosphorous, chloride, fluoride, total dissolved solids, alkalinity, sulfate, and metals. Waste rock analysis is intended to determine the net acid generation potential of the material placed in the waste rock dump during the quarter. Samples are collected daily during the quarter and classified based on their net carbonate value as sulfate, highly basic, basic, slightly basic, neutral, slightly acidic, acidic, or highly acidic. The quarterly composite sample to be analyzed is prepared on a tonnage weighted average for each classification and aggregated prior to analysis.

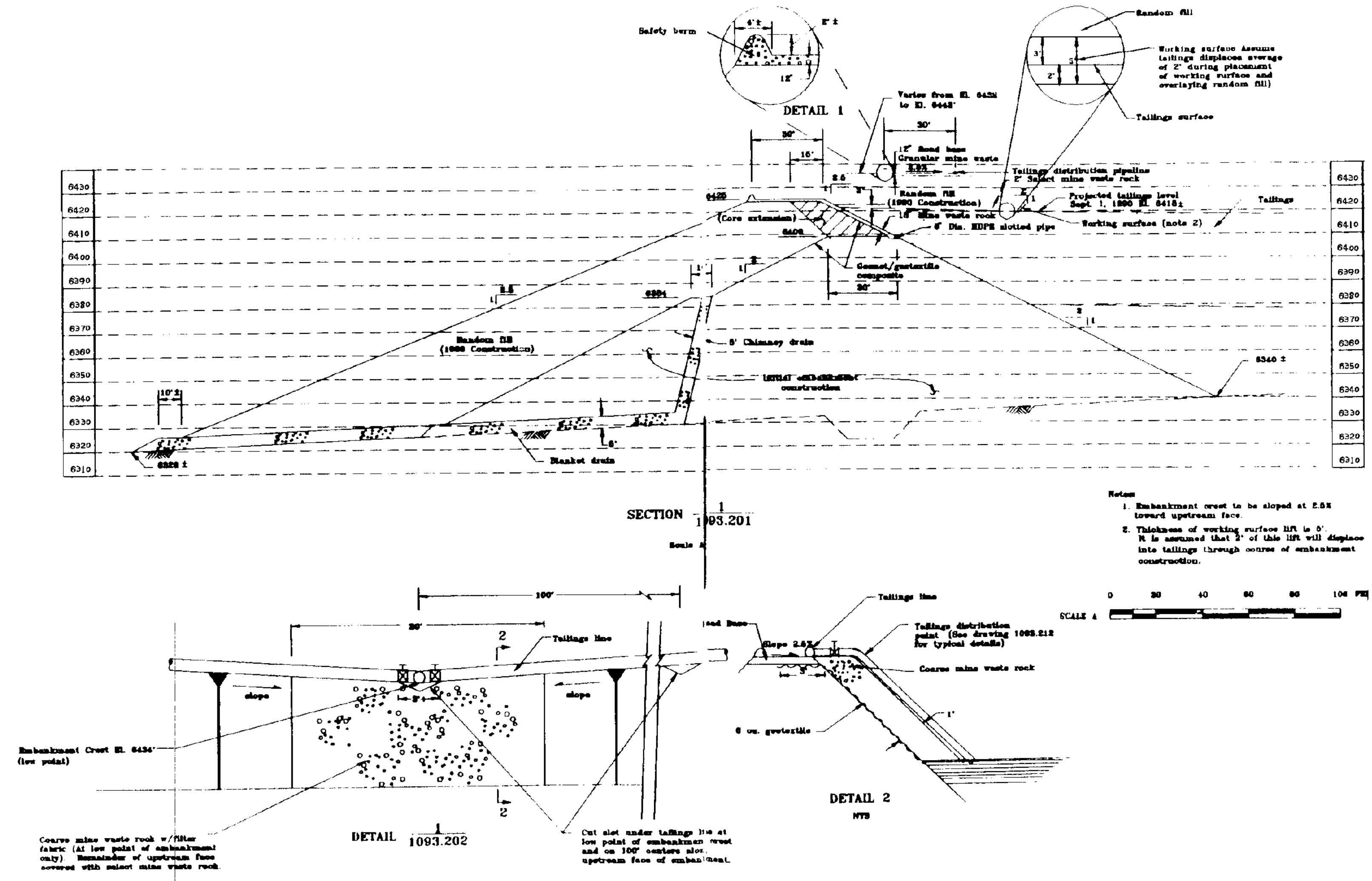
Data were available for the third and fourth quarters of 1990 and the first quarter of 1991. Results of the meteoric water mobility test for this period are presented in Appendix 5-C, Tables C-1, C-2, and C-3. Third quarter results for the waste rock analysis indicate a net acid generation potential of -10.6 tons of $CaCO_3$ for each 1,000 tons of waste. This suggests that the wastes generated during this quarter have sufficient buffering capacity to neutralize any acid solution generated by sulfidic material. Fourth quarter results show a large shift, with an acid generating potential of 5.35 tons of $CaCO_3$ for each 1,000 tons of waste. The total acid generating potential of waste rock disposed during this quarter is equivalent to the amount of acid neutralized by 5.35 tons of $CaCO_3$ for each 1,000 tons of waste rock. For the first quarter of 1991, waste rock analysis data show a net acid generating potential of 8.57 tons. In these circumstances, Newmont is required to perform kinetic testing according to State of Nevada protocol. Results of this analysis were not available; however, in the third Quarterly Monitoring Report for 1991, Newmont indicated that column studies are underway to fulfill this requirement.

The waste rock dump is not expected to require more space than the 211 acres it currently covers; however, waste rock will continue to be added, with a projected total of 62.5 million tons by 1995. At closure, the surface will be graded. Topsoil stockpiled during start-up (and which is presently stockpiled near the dump and was observed during the site visit to have a vegetative cover of grasses) will be distributed over disturbed areas and revegetated.

5.3.3 Tailings Impoundment

The Rain tailings impoundment is located downgradient from the heap leach facility and pregnant pond. According to the environmental assessment (Newmont Services, 1987b), the impoundment was originally planned to cover 109 acres. The ultimate surface area of the impoundment is now anticipated to be approximately 189 acres, with a total capacity of about 6.7 million dry tons of tailings (Newmont Gold company, 1990d). The impoundment is designed to contain the flow in the watershed from the 100-year, 24-hour storm event (the original Water Pollution Control Permit required containment for the 100 year, 72-hour storm event, with an additional two feet of free board; this was modified to the present capacity in a 1990 amendment [the permit is discussed in section 5.4.1.3]). The structure is designed to withstand the maximum credible earthquake expected in the area (Newmont Services, 1987b). Originally, the impoundment was to be a "bathtub" design, containing all fluids with no discharge beyond the tailings impoundment dam (NDEP, 1989); this has since changed, as described below. Monitoring wells were installed downgradient of the dam to verify the facility's compliance with its design standard of zero discharge.

Construction of the tailings dam began in October 1987 and was completed by the summer of 1988. Since initial construction, two additional lifts have been added to the dam to expand the storage capacity of the impoundment, and additional lifts are planned. The first lift was added in 1989, the second in 1990. Figure 5-7

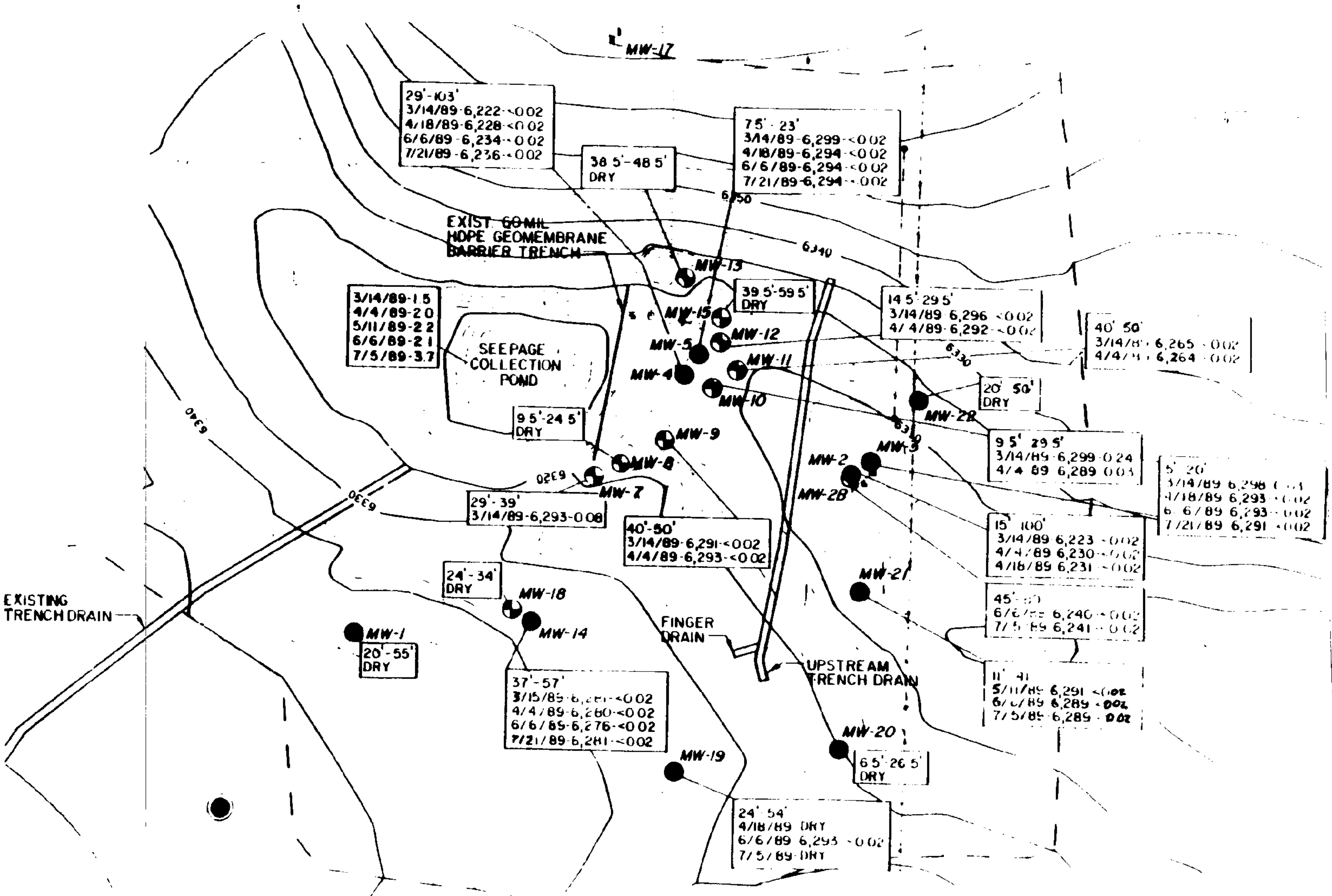

Safety berm
DETAIL 1
Random fill
Working surface Assume tailings displaces average of 2' during placement of working surface and overlaying random fill)
Tailings surface
Varies from El. 6432 to El. 6442'
12" Road base Granular mine waste
Tailings distribution pipeline
2' Select mine waste rock
Random fill (1990 Construction)
18" Mine waste rock
6" Dia. HDPE slotted pipe
Projected tailings level Sept. 1, 1990 El. 6418±
Working surface (note 2)
Tailings
(Core extension)
Geonet/geotextile composite
Random fill (1989 Construction)
5' Chimney drain
Initial embankment construction
Blanket drain
6340 ±
SECTION 1 / 1093.201
Notes
1. Embankment crest to be sloped at 2.5% toward upstream face.
2. Thickness of working surface lift is 5'. It is assumed that 2' of this lift will displace into tailings through course of embankment construction.
SCALE A
Tailings line
slope
Embankment Crest El. 6434' (low point)
Coarse mine waste rock w/filter fabric (At low point of embankment only) Remainder of upstream face covered with select mine waste rock.
DETAIL 1 / 1093.202
Cut slot under tailings line at low point of embankment crest and on 100' centers along upstream face of embankment.
Tailings distribution point (See drawing 1093.212 for typical details)
Coarse mine waste rock
6 oz. geotextile
DETAIL 2
NTS

is a cross-section of the dam showing the three phases of construction. Tailings from the mill are added to the inside face of the embankment so slimes can accumulate and form a barrier; tailings form an upstream slope away from the dam. Water ponds at the base of this slope, in the upper portion of the impoundment away from the dam. Supernatant is reclaimed and returned to the mill as process water. Keeping the supernatant pond in the upper reaches of the impoundment reduces the gradient of the phreatic line and thus the potential for seepage through the lower impoundment and the dam.

According to the environmental assessment, most of the tailings impoundment was underlain by naturally occurring highly impermeable clay. The maximum permeability was 10^{-7} cm/sec., with some areas having permeabilities of 10^{-8} or 10^{-9} cm/sec. An area on the northwest side of the future dam location consisted of alluvial material having a potentially high seepage rate. This area was to be covered with a clay liner similar to the natural clay material. The core of the dam was also to be constructed of the same material (Newmont Services, 1987b).

The initial dam structure was designed (by Call and Nicholas Inc.) as an earth fill embankment consisting of a compacted clay core with random fill shells of mine waste rock. A cutoff trench was excavated and backfilled with clayey soil to a depth of seven feet below the original ground surface prior to constructing the embankment. A near-vertical granular chimney drain was built along the length of the dam, about halfway up the downstream side of the structure (see Figure 5-7). The chimney drain is hydraulically connected to a blanket drain located at the base of the embankment on the downgradient side. The final elevation of the initial structure was 6409 feet asl (Knight Piesold, 1990).

In April 1988, during construction of the Rain facility, seepage (about 7.5 gallons per minute) was noted in the natural drainage channel about 300 feet downgradient of the tailings impoundment dam. Newmont retained Sergent, Hauskins & Beckwith to develop a mitigation plan to control seepage. Following a tracer study supervised by Geraghty & Miller, Inc., it was determined that the seepage was coming from the dam interior—liquids in the impoundment were migrating through the upstream face of the dam to the chimney drain and exiting the blanket drain on the downstream side. In June, Newmont took action to prevent continued seepage into and through the dam. To control seepage into the structure, a second keyway was excavated along the toe area on the inside face and backfilled with clayey soil (taken from a borrow pit in the upper reaches of the impoundment area--this pit then was used as temporary storage area for tailings while the impoundment remediation was underway). Newmont also placed a four-foot thick clay liner extending from the top of this keyway to the upstream toe of the dam. Soil liners (material unknown) were installed on the bedrock face forming the east abutment with the dam. Downgradient of the dam, a seepage collection pond was excavated to bedrock. Initially, this pond was pumped periodically, and later a permanent pump was installed to return seepage to the tailings impoundment. Just below the collection pond, a 60-mil HDPE barrier wall, backfilled with clay materials and capped with clay and random fill, was installed to prevent further migration of the seepage (see Figure 5-8


MW-17
29'-103'
3/14/89-6,222-<0.02
4/18/89-6,228-<0.02
6/6/89-6,234-<0.02
7/21/89-6,236-<0.02
38.5'-48.5'
DRY
7.5'-23'
3/14/89-6,299-<0.02
4/18/89-6,294-<0.02
6/6/89-6,294-<0.02
7/21/89-6,294-<0.02
6350
6340
EXIST. 60 MIL
HDPE GEOMEMBRANE
BARRIER TRENCH
MW-13
3/14/89-1.5
4/4/89-2.0
5/11/89-2.2
6/6/89-2.1
7/5/89-3.7
SEEPAGE
COLLECTION
POND
39.5'-59.5'
DRY
MW-15
MW-12
MW-5
MW-11
MW-4
MW-10
14.5'-29.5'
3/14/89-6,296-<0.02
4/4/89-6,292-<0.02
40'-50'
3/14/89-6,265-<0.02
4/4/89-6,264-<0.02
6330
20'-50'
DRY
MW-2B
9.5'-24.5'
DRY
MW-9
6340
MW-8
MW-3
MW-2
9.5'-29.5'
3/14/89-6,299-0.24
4/4/89-6,289-0.03
6320
6330
MW-7
MW-2B
29'-39'
3/14/89-6,293-0.08
40'-50'
3/14/89-6,291-<0.02
4/4/89-6,293-<0.02
15'-100'
3/14/89-6,223-<0.02
4/4/89-6,230-<0.02
4/16/89-6,231-<0.02
24'-34'
DRY
MW-18
MW-21
MW-14
EXISTING
TRENCH DRAIN
MW-1
20'-55'
DRY
FINGER
DRAIN
UPSTREAM
TRENCH DRAIN
37'-57'
MW-20
6.5'-26.5'
DRY
MW-19
24'-54'
4/18/89 DRY
6/6/89-6,293-<0.02
7/5/89-DRY

In addition, a 15- to 20-foot deep trench drain was excavated to bedrock, below the ultimate extent of the dam, parallel to the northwestern face of the impoundment and extending to the seepage collection pond (this drain is intended to direct any seepage from this end of the dam to the collection pond).

Additional monitoring wells were also constructed downgradient of the impoundment and the seepage collection pond (Newmont Gold Company, 1988e).

The tailings impoundment began operation in July 1988. Cyanide was first detected in the seepage collection pond and, to a lesser degree, in the monitoring wells located downstream of the collection pond, in October of 1988. The location of the monitoring wells in relation to the seepage pond is shown on Figure 5-8. Seepage rates increased in November 1988, causing the solution in the collection pond to overflow the HDPE barrier and enter the natural drainage (the exact distance the fluids traveled was not determined). WAD cyanide concentrations in the seepage pond ranged from a high of 11.6 mg/l in October to 63 mg/l in December of 1988; monitoring well 3 ranged from 0.17 mg/l in October to 8.8 mg/l in December. Information on cyanide concentrations for the seepage pond and monitoring wells between July 1988 and July 1989 is presented in Appendix 5-D, Tables 5-20 and 5-21. Solution chemistry of the seepage collection pond water is presented in Table 5-7

Table 5-7. Analysis of Seepage Pond Water (CP)

Sample: Seepage Pond Water (CP)	**Sample Date (values in ppm)**			
Parameter	**12-6-90**	**3-5-91**	**5-1-91**	**7-31-91**
pH (s.u.)	7.7	7.1	7.3	7.8
TDS	820	890	900	868
WAD Cyanide	0.590	0.200	0.057	0.088
Antimony	--	--	--	--
Arsenic	<0.005	<0.005	<0.005	<0.005
Barium	0.14	0.12	0.11	0.13
Bicarbonate	210	180	160	210
Cadmium	<0.005	<0.005	<0.005	<0.005
Calcium	120	130	150	130
Chloride	67	61	84	77
Chromium	<0.005	<0.005	<0.005	0.006
Copper	0.049	0.042	0.120	0.082
Fluoride	0.6	<0.5	<0.5	0.5
Iron	0.01	<0.01	<0.01	0.12
Lead	<0.005	<0.005	<0.005	0.120
Magnesium	29	33	34	28
Manganese	2.9	2.7	1.8	2.5
Mercury	0.010	0.002	0.010	0.010
Molybdenum	--	--	--	--
Nitrate	8.0	4.7	7.4	3.1
Selenium	0.010	<0.01	0.016	0.014
Silver	<0.005	<0.005	<0.005	<0.005
Sodium	100	110	82	110
Sulfate	380	360	320	400
Thallium	--	--	--	--
Zinc	0.014	<0.005	<0.005	0.008

Source: Data aggregated from quarterly reports submitted by Newmont to NDEQ as required by permit.

. Following this release, a permanent pump was installed. (As reported by Newmont on April 14, 1989, the seepage collection pond was being continuously pumped at a rate of 288,000 gallons per day, or 200 gpm.) (Newmont Gold Company, 1989e).

Newmont responded to the situation with a description of efforts to control seepage of process fluids. Sergent, Hauskins & Beckwith developed a plan to determine the source and control the seepage. In the short term, work focused on a field program of exploratory drilling and hydrologic testing to identify the seepage pathways downstream of the collection pond and develop remedial alternatives (Newmont Gold Company, 1989c). Based on these investigations, it was determined that seepage from the impoundment was confined to the alluvial material and weathered bedrock of the Webb Formation (Newmont Gold Company, 1989f).

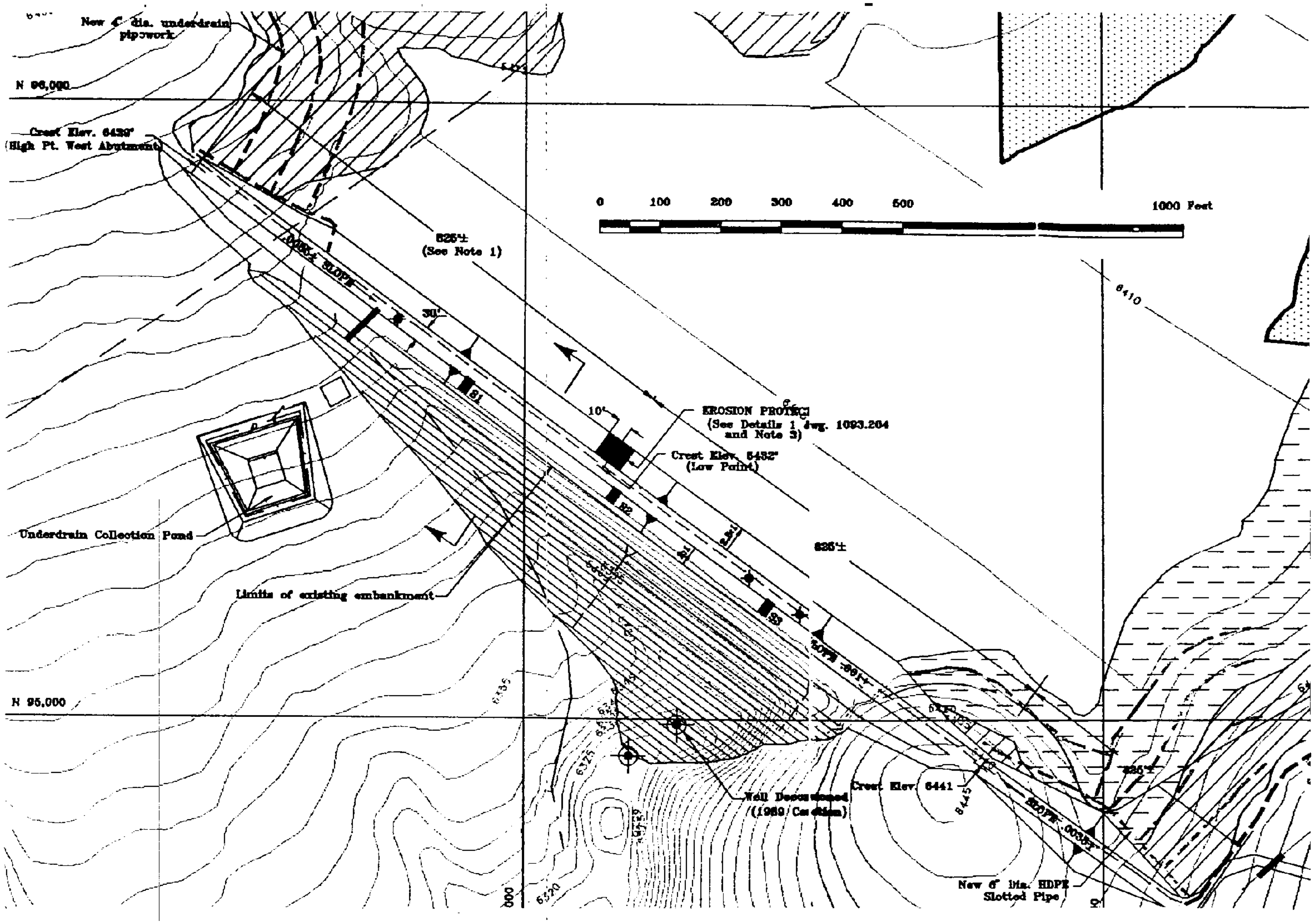
The recovery system selected by Newmont and approved by NDEP on March 15, 1989, consisted of an upstream trench drain and a downstream trench drain. The upper trench drain is located just below the seepage collection pond and HDPE barrier and is designed to intercept fluids that escape or bypass the seepage collection pond and barrier wall. It extends 160 feet across the drainage and is approximately 30 feet deep. The bottom of the trench is keyed into bedrock and slopes to a sump. An HDPE liner was installed on the downstream face and the trench was backfilled with coarse material. A pump was installed to return solution to the seepage collection pond (from which liquids were initially pumped directly to the tailings impoundment and now are pumped to the underdrainage collection pond described below).

The lower trench drain is located about 1,000 feet downstream of the upper trench drain and is intended to intercept the plume that escaped when the seepage pond overflowed in November 1988. Construction of the lower trench drain, also keyed into bedrock, was similar to that of the upper trench drain; however, it is shallower, based on field evidence that the plume is moving near to the surface. As with the upstream trench drain, a pump returns any liquids to the seepage collection pond. (Newmont Gold Company, 1989d).

A downstream lift and additional fluid management components, designed by Knight Piesold and Co., were added to the tailings impoundment dam in late 1989 (see Figure 5-7). These improvements were added both to expand the capacity of the impoundment and to improve the impoundment's environmental performance by "making a gradual transition from an essentially undrained facility to a functionally drained facility" (Knight Piesold, 1990). The clay core and blanket drain of the original dam were extended vertically and the crest of the dam was increased by 16 feet to an elevation of 6425 feet asl. In addition, an underdrainage collection system was added to control seepage as the basin fills and the pond migrates upstream. The underdrain system is also intended to aid in the consolidation of the tailings by accelerating the dewatering process (Knight Piesold, 1990).

The underdrain collection system was constructed in the upper valley areas where tailings would reach as the impoundment filled (and is to be extended as the impoundment is expanded in the future). It consists of a one-foot layer of compacted native soil (1×10^{-6} to 1×10^{-7} cm/sec) overlain with a drainage blanket/hydraulic break of 12 inches of select waste rock. Drainage lines of four-inch diameter perforated pipe are installed at intervals in the waste rock layer. Drainage from the pipes discharge to an 8-inch HDPE pipe around the area, which passes in turn through the tailings dam in a concrete encasement to an underdrainage collection pond. In addition, a transition area between the pond level at the time (late 1989) and the functional elevation of the underdrainage collection system was double-lined, with a 30-mil PVC liner over a natural soil liner (Knight Piesold, 1990).

The underdrainage collection system, as noted above, drains by gravity to an underdrainage collection pond just below the downstream face of the impoundment dam. This pond also receives pumpback from the seepage collection pond. The underdrainage collection pond is HDPE-lined with a capacity of 500,000 gallons. Solution collected in the pond is pumped back to the supernatant pond by means of a submersible pump. Figure 5-9


New 4" dia. underdrain pipework
N 96,000
Crest Elev. 6439' (High Pt. West Abutment)
825'±
(See Note 1)
0 100 200 300 400 500 1000 Feet
6410
30'
10'
EROSION PROTECT
(See Details 1 dwg. 1093.264 and Note 3)
Crest Elev. 6432' (Low Point)
Underdrain Collection Pond
Limits of existing embankment
825'±
N 95,000
Well Decommissioned (1989 Caisson)
Crest Elev. 6441
825'±
New 6" Dia. HDPE Slotted Pipe

shows the location of the underdrain system and the collection pond (Knight Piesold, 1990). As part of the quarterly monitoring required by their Water Pollution Control Permit, Newmont analyzes the underdrainage water. A chemical analysis of the underdrainage solution is presented in Table 5-8

Table 5-8. Analysis of Underdrainage Water

Sample: Underdrainage Water	Sample Date (values in ppm)			
Parameter	**12-6-90**	**3-5-91**	**5-1-91**	**8-01-91**
pH	7.6	8.0	8.0	8.0
TDS	1100	1100	1100	1200
WAD Cyanide	2.7	1.4	1.9	0.029
Antimony	<0.05	<0.05	<0.05	--
Arsenic	0.035	0.068	0.100	0.059
Barium	0.26	0.15	0.17	0.1
Cadmium	<0.005	<0.005	<0.005	<0.005
Calcium	160	160	170	180
Chloride	94	130	180	150
Chromium	<0.005	<0.005	<0.005	0.012
Copper	0.68	1.00	1.60	0.35
Fluoride	<0.05	0.5	2.1	0.9
Iron	0.61	0.50	0.20	0.29
Lead	0.032	<0.005	<0.005	<0.005
Magnesium	31	28	23	27
Manganese	2.4	1.8	1.3	2.1
Mercury	0.0099	0.0021	0.0800	0.0091
Molybdenum	0.025	0.034	0.044	--
Nitrate	7.4	8.7	14.0	7.0
Selenium	0.032	0.028	0.042	0.042
Silver	<0.005	<0.005	<0.005	<0.005
Sodium	95	110	120	110
Sulfate	490	410	360	500
Thallium	<0.05	<0.05	<0.005	--
Zinc	0.053	0.065	0.100	0.048

Source: Data aggregated from quarterly reports submitted by Newmont to NDEQ as required by permit.

A second lift, this time an upstream lift with downstream construction, and an expanded underdrainage system, was designed by Knight Piesold and Co. and built in 1990. This construction raised the dam elevation to 6,432 feet asl. Upstream fill construction consisted of earth and waste rock surrounding an extension of the dam's clay core.

A one- to two-foot layer of waste rock was placed on the upstream face; fluid that collects in this system will be drained through collector pipes to the underdrainage collection pond. Future lifts of similar upstream construction are planned, which will raise the final elevation of the dam to 6,475 feet asl. The impoundment's ultimate design capacity is for 6.7 million dry tons of tailings. Designed fluid capacity for the operational pond is for up to 150 acre-feet of water, plus flow from the 100-year, 24-hour storm event, with at least three feet of freeboard. (Knight Piesold, 1990)

With the completion of the 1989 and 1990 expansions and construction, all fluids collected by the seepage collection pond, upper and lower trench drains, and the underdrainage collection system drains by gravity or is pumped to the underdrain collection pond. From there, the solution is pumped back to the tailings impoundment supernatant pond where it is available for recycle to the mill.

Newmont reported the chemistry of the tailings solids as part of the Quarterly Monitoring Report until the third quarter of 1990. Table 5-9 is a summary of monitoring results.

Table 5-9. Chemical Analyses of Tailings Solids for First Three Quarters, 1990

Analyte	Concentrations in mg/kg except as noted		
	January 15, 1990	April 4, 1990	Third Quarter, 1990
Cadmium	0.0086	0.0039	0.0063
Copper	0.0250	0.0065	0.019
Mercury	0.0210	0.023	0.019
Lead	< 0.0150	<0.00025	0.0091
Zinc	0.048	0.007	Not reported

Newmont's "Tentative Permanent Closure Plan" (Newmont Gold Company, 1990d) indicates that limiting runon onto the impoundment and removing existing fluids are primary goals of closure. (According to Newmont, the "Tentative Permanent Closure Plan" is "tentative" in the sense that it has not yet been implemented and may be amended as events require, not because of any lack of development.) Supernatant from the tailings impoundment will be pumped to the leach facility, as will solution collected in the underdrainage collection pond and the seepage collection pond. By controlling runon and disposing of supernatant, Newmont anticipates a "gradual draining of the noncapillary fluid from the facility;" this in turn is anticipated to result in a cessation of seepage into the underdrain system and the seepage collection pond. If drying of the tailings impoundment surface presents a wind erosion problem, the surface may be covered with waste rock and/or native grass hay and/or windbreaks may be used. In addition, solid tailings will be sampled on an annual basis. The environmental assessment (Newmont Services, 1987b) indicated that the impoundment area would be covered with waste rock and that tests would be undertaken to determine the feasibility of establishing vegetation on that waste rock.

5.3.4 Water Management

Process water is carefully managed at the facility. According to Newmont, the Rain operation consumes fresh water at a rate of approximately 100 gpm on an annual basis. During dry periods, consumption may reach or exceed 600 gpm. The average usage represents less than 10 percent of the water moving through the system at any given time and, assuming the water volume onsite remains constant, this amounts to 140,000 gpd. Most water loss is due to evaporation from the tailings impoundment, heap leach, and road watering to control dust. Water from the tailings impoundment and leach circuit are recycled to the mill for distribution. A small volume of additional water is collected from local surface-water run-off control and from the waste rock dump in the form of acid drainage and transferred to the tailings impoundment. Similarly, seepage from the tailings impoundment and any leachate from the leach pads and solution ponds are returned to the tailings impoundment. As described above, Newmont expects seepage from the tailings impoundment to be reduced or to end following closure, and also anticipates that there will be little or no infiltration and seepage from the waste rock dump following closure.

5.3.5 Other Materials and Wastes

Table 5-10 lists several of the materials and wastes handled by the Rain facility. The facility uses a small landfill (Class III under Nevada regulations) to dispose of solid waste generated by the facility. During the site visit, participants observed items such as paper, cardboard, and empty reagent drums in the trench landfill. Hazardous wastes or petroleum liquids are not disposed of in the landfill. A permit was issued for the landfill in October 1989 by the Nevada Waste Management Bureau. The landfill is located on the south rim of the mine pit at an elevation of approximately 6750 feet. As the trench is filled it is covered with soil material. The average amount of waste generated is 40 cubic yards of uncompacted waste per week: 12 cubic yards from the mill and office sources and 28 from the truck shop.

Table 5-10. Selected Wastes and Materials Handled at Rain Facility

Material/Waste	Amount/Disposition
Lubricating and hydraulic oils, oil from HOTSY skimmer, antifreeze	Transported to waste oil recycling facility in California.
Sodium cyanide	Stored in bins, introduced into mill line at 0.28 lb/ton of ore, into barren solution at about 214 pounds/day.
Sodium hydroxide (pelletized)	Introduced into mill line at 50 lb per 3,000 pounds cyanide; into leach line at about 437 pounds/day.
Lime	Stored in bins, added to mill ore at about 1.7 lb/ton of ore. Also added to top of heap.
Cement	Stored in bin, added to leach ore at 8 lb/ton of ore.
Surfactants	Stored in drums, added to crushing/grinding circuit at 10 cc/minute.
Polymaleic acid antiscalant	Stored in bags, added to mill water supply at 24 cc/min, to barren line at 14 cc/min.
Magnesium chloride	Stored in tank, mixed with water for dust control on roads and other area.
Ammonium nitrate/fuel oil	Used as blasting agent.
Mill slurry trash	Collected at trash screens at about one ton/week, hauled to heap.
Water from HOTSY steam cleaner	Transferred to tailings impoundment.
Solid waste	About 40 cubic yards/week, disposed in onsite trench landfill.
Sewage effluent and sludge	Supernatant from lagoons (one gpm) pumped to tailings impoundment. Disposition of sewage sludge not determined.

In an effort to minimize waste associated with facility maintenance such as metal cleaning, the Rain operation is experimenting with a HOTSY (manufacturer's name) steam cleaner. In the past, Safety-Kleen Corporation supplied an asphalt solvent containing trichlorethylene, which was returned to Safety-Kleen for regeneration. The shipments were manifested in accordance with Nevada hazardous waste regulations. The frequency and sizes of shipments were not determined (a shipment on June 12, 1991, involved 258 gallons). The new process uses citrus-based solvents in conjunction with a compound of graphite and aluminum. The new product was reported to be effective, but somewhat caustic. One of the features is a skimmer device that separates oil from water. The oil joins other waste oils (see below); the water is added to the tailings line. According to the environmental assessment, sanitary sewage was to be disposed through septic tanks and leach fields (Newmont Services, 1987b). During the site visit, Newmont representatives indicated that sanitary sewage is treated in a settling lagoon and the supernatant added to the tailings line at an average rate of 1.0 gpm. Information on generation rates or ultimate disposal of sludge from the lagoon was not obtained.

Waste oil is stored in on-site tanks and periodically picked up and transported to a waste oil recycling facility in California. The oil, which is not a hazardous waste, is manifested in accordance with California requirements. The frequency and size of shipments were not determined. One shipment, on January 1, 1991, involved 6,400 gallons.

5.4 REGULATORY REQUIREMENTS AND COMPLIANCE

Prior to operating the Rain mine and mill, multiple permits and approvals were required from State and Federal agencies. Table 5-11

Table 5-11. State and Federal Permits and Approvals, Rain Facility

State	
Department of Conservation and Natural Resources, Division of Water Resources;	
Well and Water Appropriation (one for each of four wells)	Permit Numbers 50664, 50665, 50666, and 46346
Construction of Tailings Dam	Permit Number J-261
Construction of Pregnant Pond Dam	Permit Number J-276
Department of Wildlife	
Industrial Artificial Pond	Permit Number 3435
Department of Conservation and Natural Resources, Division of Environmental Protection	
Water Pollution Control	Permit Number NEV87011
Surface Disturbance (air)	Permit Number 1321
Construction of Primary Crushing Circuit (air)	Permit Number 1617
Construction of Secondary Crushing Circuit (air)	Permit Number 1618
Construction of Portec Cement Bin (air)	Permit Number 1619
Construction of Stanco Projects Lime Bin (air)	Permit Number 1748
Division of Health	
Operate a Public Water System	Permit Number EU-2064-12NC
Operate a Sewage Treatment System	Permit Number EL 2645
Waste Management Bureau	
Class III Landfill	Number not determined
Federal	
U.S. Department of Interior, Bureau of Land Management	
Rain Plan of Operations, Approved in 1986	
Rain Final Environmental Assessment, March 1987	
Amendment to the Final Environmental Assessment, Rain Access Road, October 1987	
Amendment to the Final Environmental Assessment, Water Pipeline, 1987	
Amendment to the Final Environmental Assessment, Powerline, 1987	
U.S. Environmental Protection Agency	
RCRA Identification Number	NVD 982486300.

lists the permits or approvals obtained by Newmont for the Rain facility organized according to granting agency, type of permit, and the identification number. The first section below describes major State permits, and is followed by sections on major Federal approvals.

5.4.1 State of Nevada

This section describes permits issued to the Rain facility by the State of Nevada. The first subsection describes the new reclamation permit that was obtained by October 1, 1993. This is followed by subsections that describe water (section 5.4.1.2) and air (5.4.1.3) permits.

5.4.1.1 Reclamation Permit

Nevada Administrative Code 519A.010 to 519A.415 requires facilities active on or after October 1, 1990, to obtain an exploration or mining permit that provides for reclamation. Facilities active on October 1, 1990, including the Rain facility, had to obtain the permit by October 1, 1993. Permits have a life-of-mine term and are intended to ensure reclamation is sufficient to return land to a "safe, stable condition consistent with the establishment of a productive post-mining use of the land and the safe abandonment of a facility...." (NAC 519A.075). BLM-approved reclamation will satisfy the State (NAC 519A.255).

Reclamation plans must include, among other things, full descriptions of the affected land and operations (including roads); nearby waters; proposed productive post-mining use of the land; schedules for initiation and completion of reclamation activities; and proposed revegetation plans. State regulations contain requirements for each of these components and provide authority to require certain types of reclamation (NAC 519A.345). Financial assurance, based on the costs of reclamation, is required, and the regulations specify the types of surety that are acceptable (NAC 519A.350 to 519A.390). Representatives of Newmont at the time of the site visit indicated that the company was in the process of preparing the application for this permit.

5.4.1.2 Water Permits

Well and Water Appropriation Permits (one for each of four water wells in Dixie Flats)

According to the environmental assessment, the Rain facility was to require about 525 gpm of new water for the operation (as noted previously, actual requirements range from about 50 to over 500 gpm, depending on the season). During facility planning, the only nearby sources known to have this capacity were in the Dixie Flats area, several miles away. Exploratory drilling was conducted to locate a source closer to the facility but no reliable sources were located. Ultimately, wells in Dixie Flats were selected; an amendment to the environmental assessment was prepared for the right-of-way across public land. The NDEP Division of Water Resources issued Water Appropriation Permits for wells located in Dixie Flats, six miles east of the Rain facility. Water from these wells is conveyed by pipeline to the Rain facility. (The permits were not obtained or examined by the site visit team.)

Water Pollution Control Permit

Nevada Revised Statutes (NRS) 445.131 through 445.354 and implementing regulations (Nevada Administrative Code--NAC) protect ground and surface waters of the State and are implemented by the Division of Environmental Protection. Regulations specific to the "design, construction, operation and closure of mining operations" (NAC 445.242 through 243) were added in 1989. Regulatory requirements are placed on facilities, including the Rain facility, in Water Pollution Control Permits.

The regulations include minimum design and monitoring criteria for various process and waste components. When no longer active, tailings impoundments must be characterized and covered to protect wildlife. Spent ore from cyanide leaching must be rinsed until weak acid dissociable (WAD) cyanide levels in the effluent are less than 0.2 mg/l, the pH is between 6 and 9, and the effluent does not degrade waters of the State (unless alternative limits are approved).

This permit is the means by which the State has placed requirements on all components of the Rain facility to protect both ground and surface waters. The Rain facility applied for their Water Pollution Control permit in December 1986; Permit NEV87011 was issued on April 25, 1988 and remains in effect for five years (NDEP, 1988). The permit has been revised twice since it was first issued, the first time in September 1990, the second in January 1991 (NDEP, 1990).

The permit (Section II.C) defines the Rain fluid management system as including the mill and associated processes and piping, the leach pad and French drains, lined solution ditches, the pregnant pond and leak detection system, the tailings impoundment and trench drain, the underdrainage collection system and pond, the seepage collection pond and barrier wall, and the upstream trench drain (the 1990 and 1991 revisions added the components below the tailings dam--trench drains, seepage collection pond, underdrainage collection pond--to the fluid management system, from which there may be no discharge to surface waters). The permit requires Rain to ensure the fluid management system contains all process solutions and the flow from the 100-year, 24-hour storm event (Section II.A.2). Permit limits include zero discharge to surface waters; for ground water, releases may not cause violations of drinking water standards or result in WAD cyanide concentrations over 0.2 mg/l (Section II.A.3). Other limits include flow limits for the various leak detection sumps: none may exceed 150 gpd averaged quarterly or 50 gpd averaged annually. In addition, Newmont must notify the State when static evaluations of waste rock show less than 20 percent neutralization capacity; if kinetic tests indicate acid generation, Newmont must propose methods for containment and evaluate the impact on final stabilization.

The permit also has required Newmont to submit (and revise) a number of reports and plans, including an "Emergency Response Plan" and a "Permanent Closure Plan." Besides the monitoring requirements described below, the permit also requires annual reports on water supply analytical results; spill and release synopses; summaries of operations; effectiveness of seepage pond and upstream trench drain; and summary reports on the downstream trench drain system.

Table 5-12. Permit NEV87011: Monitoring Locations, Parameters, and Frequencies

Monitoring Location	Parameter	Frequency
Water Supply	Profile I[1]	Annually
Monitoring wells MW2B, MW-3, MW-16, MW-23	Profile I	Quarterly
Leach Pad French Drains: East Drain and West Drain	Average Flow (gpd), pH, Free CN Profile I	Weekly Quarterly
Leak Detection Sumps (fluid cap.): Pregnant Pond (30 gal.) Underdrain Collection Pond (30 gal.)	Average Daily accumulation (gpd)	Weekly
Waste Rock/Overburden generated during the quarter	Meteoric Water Mobility Analysis and Acid generation-acid neutralization potential	Quarterly
Pregnant & Barren Leach Solution	Profile II[2]	Quarterly
Tails Water (TW), Reclaim Water (RW), Underdrainage Water (UW)	Profile II	Quarterly
Seepage Pond (CP)	Profile I Pumpback flow	Quarterly Weekly
Upstream Trench Drain UTD)	Profile I Pumpback flow	Quarterly Weekly
Downstream Trench Drain (DTD)	Profile I Pumpback Flow	Quarterly Weekly

1. Profile I includes:

Alkalinity	Chloride	Iron	Nitrate	Silver	WAD cyanide
Arsenic	Chromium	Lead	pH	Sodium	Zinc
Barium	Copper	Magnesium	Potassium	Sulfate	
Cadmium	Fluoride	Mercury	Selenium	TDS	

2. Profile II includes all the constituents of Profile I and the following:

Aluminum	Bismuth	Gallium	Manganese	Phosphorus	Thallium
Antimony	Calcium	Lanthanum	Molybdenum	Scandium	Tin
Beryllium	Cobalt	Lithium	Nickel	Strontium	Titanium
					Vanadium

The Water Pollution Control Permit for the Rain facility contains extensive monitoring and reporting requirements. It stipulates the location, frequency, and parameters to be monitored. NDEQ updated specific conditions for the facility when the permit was revised in January 1991. Monitoring requirements include a variety of parameters grouped by Profile. Profile I consists of the standard drinking water parameters.

Profile II is a list of 40 elements, metals and compounds selected by the NDEQ; some of these overlap with those required by Profile I. Table 5-12 presents the monitoring requirements (including locations, parameters, and frequencies) in Permit NEV87011 as of January 1991; monitoring locations are identified in Figure 5-2.

Monitoring requirements have been modified as facility operations have changed since permit issuance. For example, construction of the upstream trench drain lead to the abandonment of monitoring wells 2, 7, 8, 9,10, 11, 12, 13, 17, and 18. Monitoring requirements also changed to address problems with specific facility units in the fluid management system such as the waste rock pile and tailings impoundment. For example, monitoring wells 2b, 3, 16, and 23 were included in the permit to monitor seepage. Similarly, weekly flow and quarterly analysis of Profile I constituents from the seepage collection pond and trench drains below the tailings dam are now required. The permit also provides that Newmont may request a reduction in the number of elements and frequency of analysis after one year of complete monitoring, based on justification other than cost.

Specific monitoring data for the waste rock, pregnant and barren solutions, and tailings and reclaim water are presented in the preceding discussions of those topics. Table 5-13

Table 5-13. Discharges from Monitoring Locations Reported in Quarterly Monitoring Reports

Monitoring Location	4th, 1990	1st, 1991	2nd, 1991	3rd, 1991
West French Drain				
Flow (gpm)	0 (dry)	0.05	2.02	1.9
pH (ave.)	"	8.0	7.8	7.3
CN (free)	"	<0.1	<0.1	<0.1
East French Drain				
Flow (gpm)	0 (dry)	0.04	0.64	1.87
pH (ave.)	"	7.5	7.5	7.6
CN (free)	"	0.1	<0.1	<0.1
Pregnant Pond PPS Flow (gpm)	NA	0.857	0.464	0.050
Underdrainage SW Flow (gpm)	NA	0.000	0.000	0.000
Seepage Pond CP Flow (gpm)	NA	7.83	21.10	5.96
Upper Trench Drain UTD				
Flow (gpm)	0.81	2.24	0.95	0.57
pH (ave.)	7.2	7.0	7.45	7.2
CN (WAD)	0.510	0.072	0.050	0.040
Lower Trench Drain DTD				
Flow (gpm)	1.55	1.91	3.12	0.13
pH (ave.)	7.4	7.4	5.8	7.3
CN (WAD)	0.320	0.110	0.005	0.020

(Source: Quarterly Reports supplied by the State of Nevada and the Rain facility) is a summary of monitoring data for the French drains, pregnant pond, underdrain collection pond, and the upper and lower trench drains for the four quarters ending August 1991, as provided in the Quarterly Monitoring Reports. As available, pH and cyanide as free or WAD are included for each discharge point. Water from these sources is returned to the tailings impoundment.

5.4.1.3 Air Permits

The Rain facility was granted Point Source Particulate Permits under the authority of Nevada Revised Statutes (445.401 - 445.601) and Administrative Codes (445.430 - 445.846). As part of the construction permit for the primary and secondary crushing circuit, the Rain facility applies water and surfactant at the points of dust generation. These include the jaw feeder, the intake to the jaw crusher, the point where cement is added, and at the conveyor belt drop point from the radial stacker. Sprays are also located at the discharge belt from the cone crusher and the final drop point to the stockpile. The dust suppression system is inspected annually by Bureau personnel. In the information available, no mention was made of the baghouses used to control dust from the cement and lime storage bins.

5.4.2 Plan of Operations (Bureau of Land Management)

A portion of the Rain facility is located on public land managed by the Bureau of Land Management (BLM). In compliance with the National Environmental Policy Act (NEPA), Newmont Services Ltd. completed a draft environmental assessment (EA) for the Rain Project in December 1986 under the direction of BLM. The draft EA was revised and a final EA was issued in March 1987. The Elko District Manager for BLM signed a Decision Notice and Finding of No Significant Impact for the Rain proposal on May 8, 1987. The only conditions set forth in BLM's Decision were specific waste dump reclamation issues and those specified in Newmont's Plan of Operations (U.S. Department of Interior, 1987; Newmont Services, 1987b).

For mining facilities that disturb more than 5 acres of land the BLM requires the owner to submit a Plan of Operations. The BLM approved Newmont's Plan in 1986; a copy of the Plan was submitted with the Final EA in 1987. The Plan is a brief statement describing the size of the facility, estimates of material to be moved, a description of the mill and leach circuit, environmental protection measures to be followed, and reclamation activities. Also included are Process Design Criteria and Flow Diagrams.

Because no portions of the site on BLM lands involve cyanide operations (only portions of the waste rock dump and roads are on BLM lands), BLM's 1990 cyanide policy is not applied to the site. (The BLM policy incorporates Nevada regulations on water pollution control, protection of wildlife, and reclamation. The only substantive difference, were Rain's cyanide operation on BLM land, would be a quarterly inspection by BLM.) In addition, BLM policy requiring full bonding will defer to the State's bonding requirement, which is due to be fully implemented at the Rain facility in 1993.

5.4.3 Hazardous Waste (U.S. Environmental Protection Agency)

The Environmental Protection Agency has assigned a RCRA identification number to the Rain facility since they are (or were) a small-quantity generator of petroleum-based cleaning solvents which were used as part of operations and maintenance. Safety-Kleen transported these spent solvents off-site (for regeneration). This service has been discontinued; it was replaced with the HOTSY steam cleaning process described in Section 5.3.5.

5.5 REFERENCES

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Nevada Division of Environmental Protection. 1989 (February 3). Finding of Alleged Violation and Order under Water Pollution Control Permit NEV87011.

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Newmont Gold Company. 1987 (April 20). Application for a Water Pollution Control Permit - Short Form M. Submitted to Nevada Division of Environmental Protection (shows receipt of February 27, 1987--prior to applicant's signature date).

Newmont Gold Company. 1988a (January 14). Letter from D.A. Deming, NGC, to P. Liebendorf, Nevada Division of Environmental Protection. Subject: Suggested language for draft permit.

Newmont Gold Company. 1988b. "Rain Project Spill Emergency Response Plan." Submitted to Nevada Division of Environmental Protection on August 17, 1988. (See also Newmont, 1990, for Emergency Response Plan for Environmental Releases.)

Newmont Gold Company. 1988c. "Rain Project Closure Plan." Submitted to Nevada Division of Environmental Protection on August 17, 1988.

Newmont Gold Company. 1988d (August 30). Letter to Paul Liebendorfer (NDEP) from Steve Botts concerning the release of sodium cyanide and tailings slurries on August 19 due to a plug in the tailings line.

Newmont Gold Company. 1988e (November 22). Letter to Paul Liebendorfer (NDEP) from Ann Tyson concerning summary of remedial action taken by Newmont to contain tailings seepage.

Newmont Gold Company. 1988f (December 14). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Department of Environmental Protection. Re: Rain Permit, NEV87011 (Sampling results for monitoring system downstream of tailings and proposed modification to permit NEV87011.)

Newmont Gold Company. 1988g (December 21). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Department of Environmental Protection. Re: Pregnant Pond Sump Discharge; Rain Permit NEV87011.

Newmont Gold Company. 1989a (January 5). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Department of Environmental Protection. Subject: Status report on (I) Pregnant liquor detection in recovery system, (II and IV) tailings dam recovery system, status report and monthly monitoring results

Newmont Gold Company. 1989b (February 1). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Department of Environmental Protection. Re: Rain Project Status; NEV87011 (Status report on leach pad/pregnant pond action, tailings impoundment collection system).

Newmont Gold Company. 1989c (February 15). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Department of Environmental Protection. Re: Rain Project; NEV87011 (Response and to NDEP Finding of Alleged Violation and Order--description of remedial actions taken).

Newmont Gold Company. 1989d (March 23). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Division of Environmental Protection. Re: Rain Remedial Action; nev87011 (status report on tailings remediation: construction of trench drains and associated monitoring wells downstream of seepage collection pond).

Newmont Gold Company. 1989e (April 14). Letter from A.M. Tyson, NGC, to P. Liebendorfer, Nevada Division of Environmental Protection. Re: Rain Remediation Action; NEV87011 (status report on tailings remediation: trench drains and associated monitoring wells).

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Newmont Gold Company. 1990a (April 23). "Newmont Gold Company Rain Fluid Management System Best Management Plan." Proposed plan submitted with letter from D. Baker, NGC, to P. Liebendorfer, Nevada Department of Environmental Protection.

Newmont Gold Company. 1990b (June 28). Letter to Tom Fronapfel (NDEP) from David Baker concerning response to AMD NOV.

Newmont Gold Company. 1990c (October). "Rain Emergency Response Plan for Environmental Releases." Submitted to Nevada Division of Environmental Protection.

Newmont Gold Company. 1990d (December). Tentative Permanent Closure Plan. Prepared by Newmont Gold Company, Department of Environmental Affairs.

Newmont Gold Company. 1990e (December). Response to Nevada Bureau of Air Quality Notice of Alleged Violation No. 830, Rain Operation. **Note:** State NOV letter not on file with NDEQ.

Newmont Gold Company. 1991a (January 15). Letter from E. Hamer, NGC, to T. Fronapfel, Nevada Division of Environmental Protection. Subject: Fourth quarter 1990 monitoring report and status report.

Newmont Gold Company. 1991b (September). Letter from David Baker, NGC, to Stephen Hoffman, Environmental Protection Agency. Re: transfer of following documents requested during the Site Visit: (1) block diagrams of the mine, mill, heap leach, and tailings processes; (2) Air Quality Permit Summary as of August 1991; (3) site map with elevation contours; (4) estimated uncompacted garbage production; (5) wildlife mortality reports dating back to 1988; (6) sewage flow rates.

Newmont Services Ltd. 1987a (February 11). Letter from N. Greenwald, Newmont, to H. Van Drielen, Nevada Division of Environmental Protection. Subject: Request for issuance of groundwater protection permit and submission of supporting documents (sections of draft environmental assessment, plan of operations, reports on geotechnical investigations for leach pad and tailings impoundment.

Newmont Services Ltd. 1987b (March). Final Environmental Assessment, Rain Project and Amendments for the Access Road, Power Line, and Water Supply Line. Prepared by Newmont Services, Tucson, Arizona.

Steffen Robertson and Kirsten. 1990 (October). Rain Project Solution Collection and Return System Design Report. Prepared for Newmont Gold Company by Steffen Robertson and Kirsten (U.S.), Inc., Lakewood, Colorado.

U.S. Department of the Interior, Bureau of Land Management, Elko District Office. 1988 (December 27). Letter from L. Sweeney, BOM, to L. Dodgion, Nevada Division of Environmental Protection. Subject: Request for meeting on Rain facility tailings impoundment leaks.

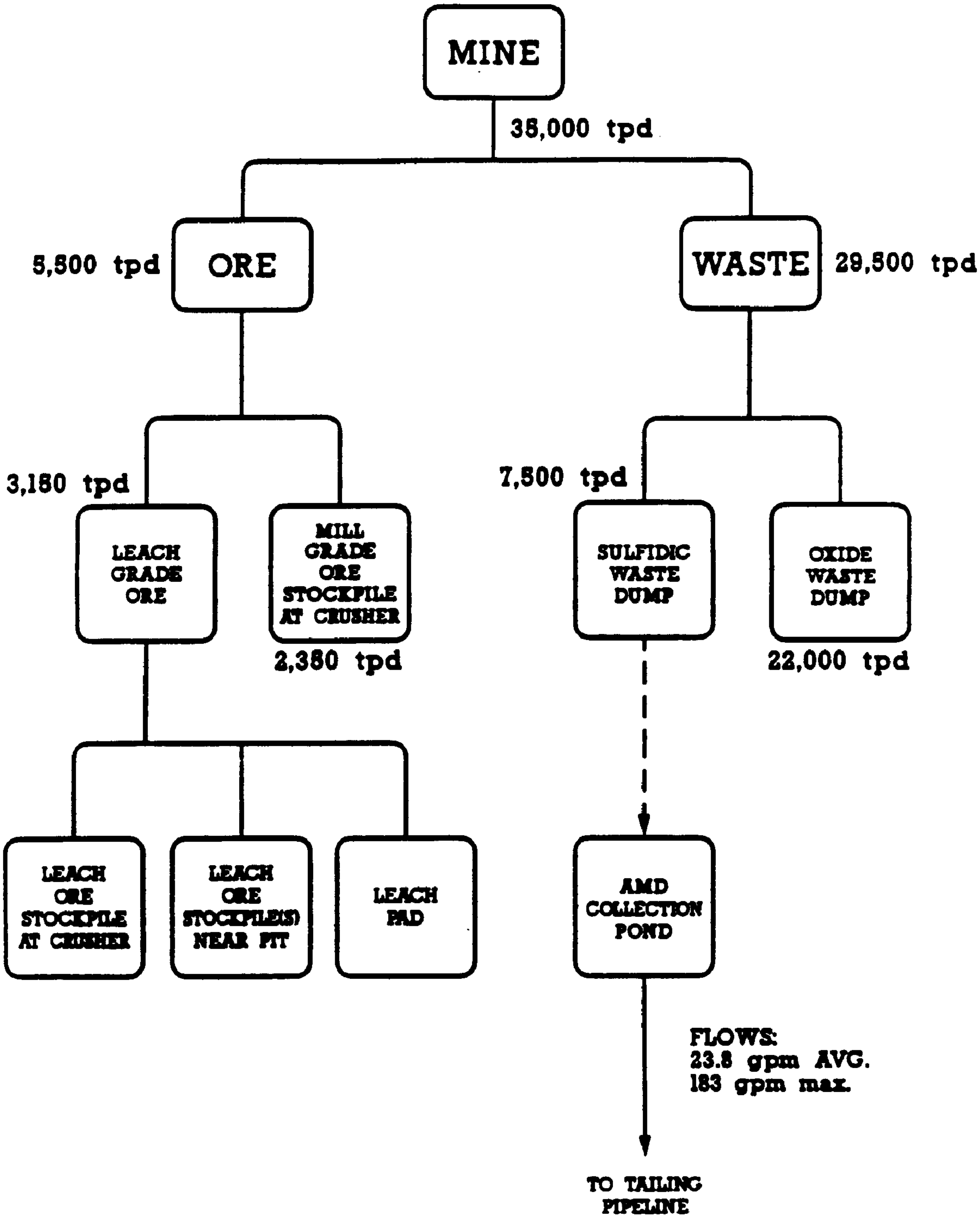
U.S. Department of the Interior. 1987c (June 3). Letter to Joy McBeth (Newmont) from Tim Hartzell (Elko District Manager, BLM) concerning 1) water rights to local springs, and 2) Decision Notice and Finding of No Significant Impact.

U.S. Environmental Protection Agency. 1991 (August). Telephone Checklist: Newmont Gold Company, Rain Mine. Completed August 16, 1991, with David Baker, Vice President for Environmental Affairs and Steve Hoffman, EPA Office of Solid Waste.

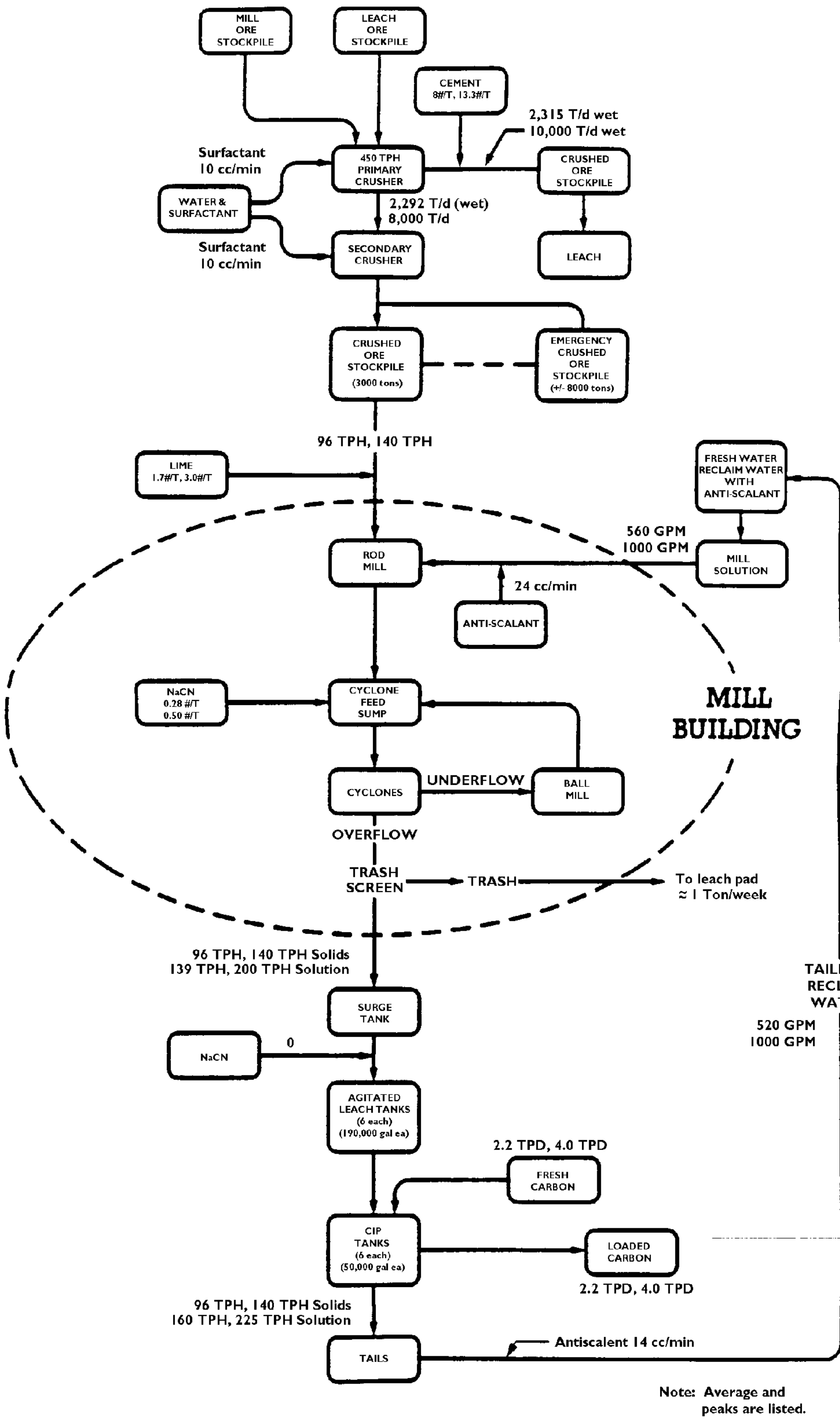
APPENDIX 5-A

FLOW CHARTS OF THE RAIN MINE, MILL, HEAP LEACH, AND TAILINGS PROCESSES

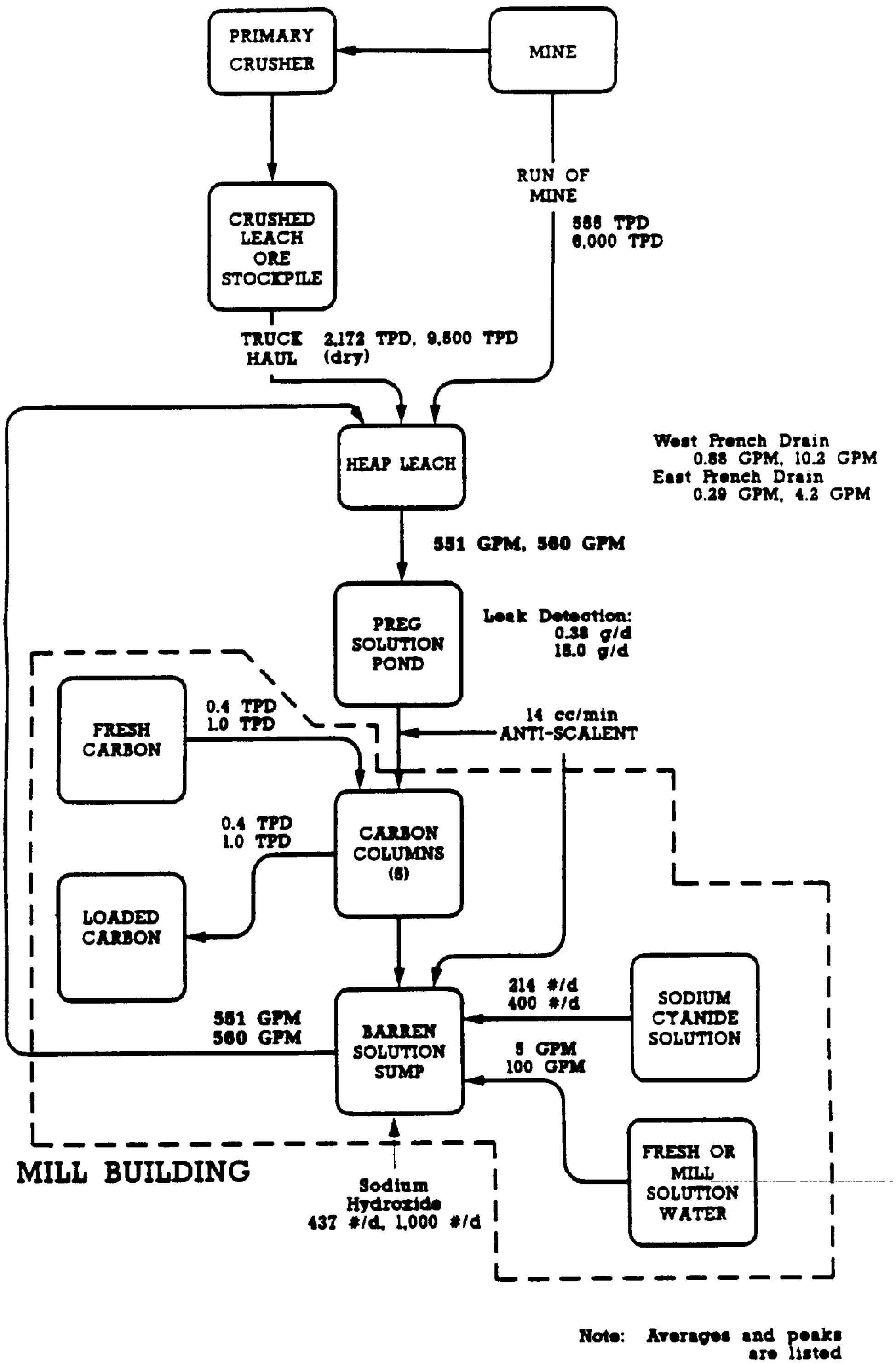
MINE


MINE
35,000 tpd
ORE
5,500 tpd
WASTE
29,500 tpd
3,150 tpd
LEACH GRADE ORE
MILL GRADE ORE STOCKPILE AT CRUSHER
2,350 tpd
7,500 tpd
SULFIDIC WASTE DUMP
OXIDE WASTE DUMP
22,000 tpd
LEACH ORE STOCKPILE AT CRUSHER
LEACH ORE STOCKPILE(S) NEAR PIT
LEACH PAD
AMD COLLECTION POND
FLOWS:
23.8 gpm AVG.
183 gpm max.
TO TAILING PIPELINE

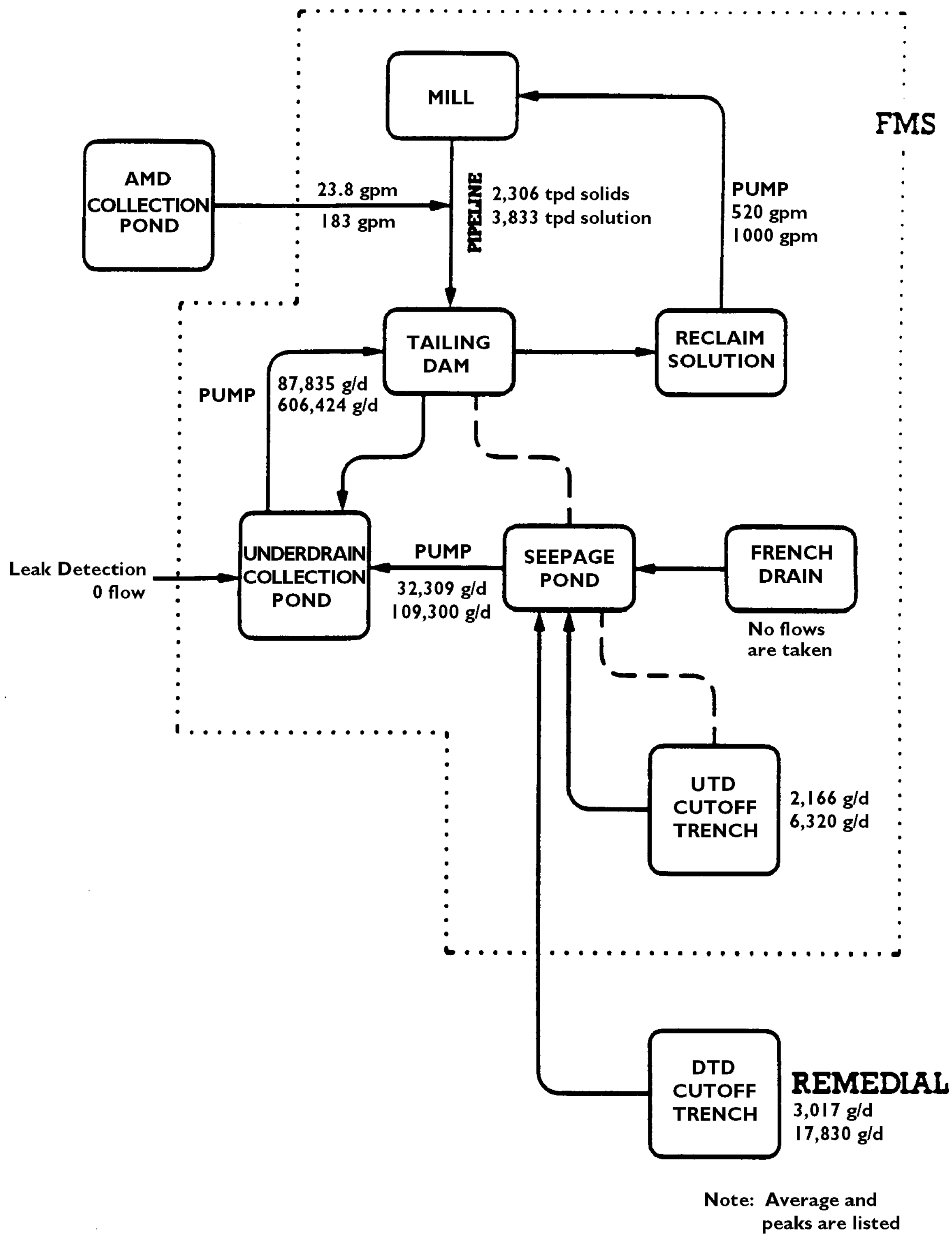
MILL 3 PROCESS



HEAP LEACH PROCESS

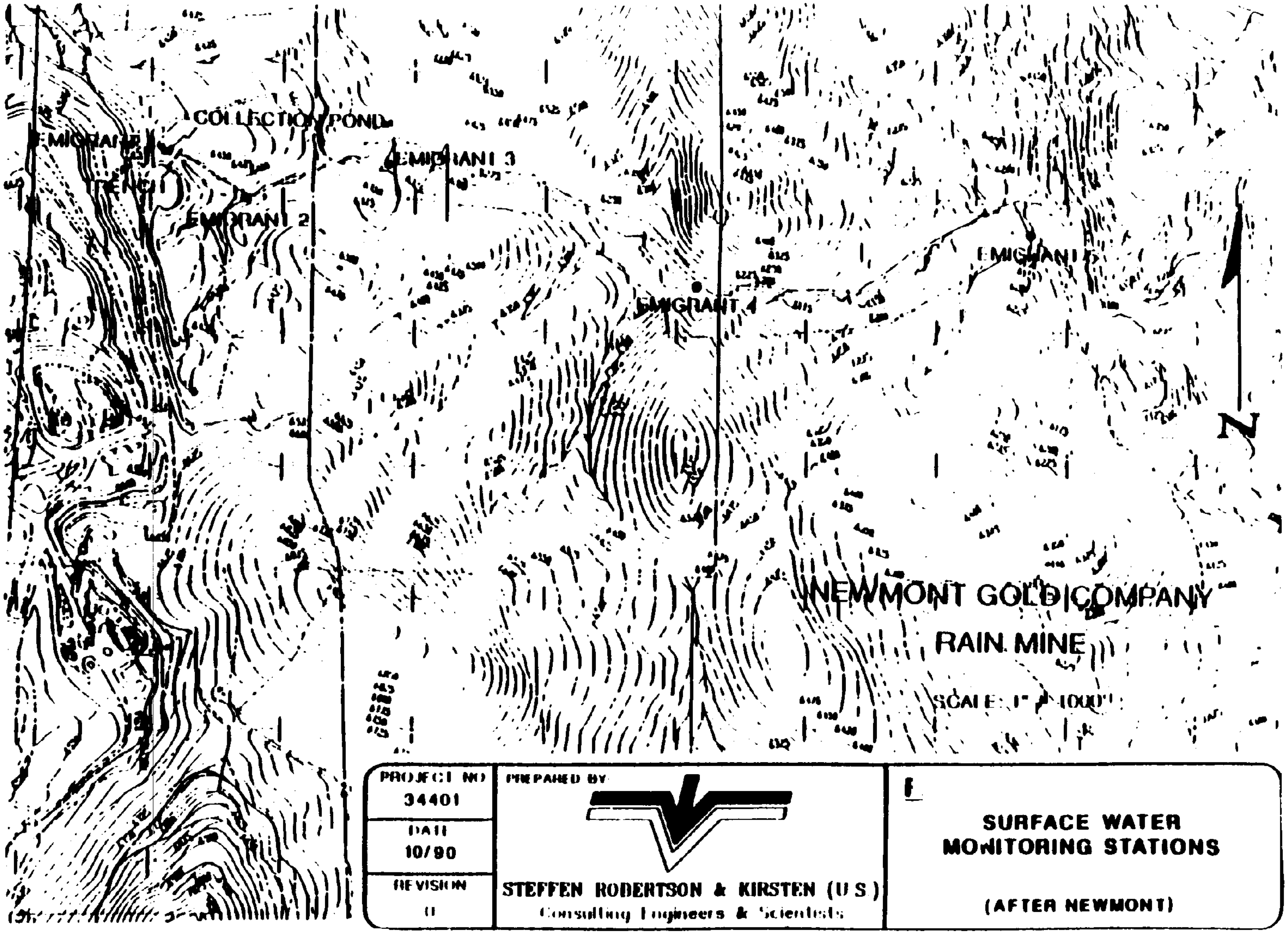


TAILING PROCESS



APPENDIX 5-B

CHEMICAL ANALYSIS OF FIVE SITES ALONG EMIGRANT SPRINGS



COLLECTION POND
EMIGRANT 3
EMIGRANT 2
EMIGRANT 5
EMIGRANT 4
NEWMONT GOLD COMPANY
RAIN MINE
N
PROJECT NO
34401
DATE
10/90
REVISION
0
PREPARED BY
STEFFEN ROBERTSON & KIRSTEN (U.S.)
Consulting Engineers & Scientists
SURFACE WATER
MONITORING STATIONS
(AFTER NEWMONT)

Table 5-14. Water Quality and Sediment Data, Rain Facility, June 15, 1990

Parameter	EMIG 1	EMIG 1B	EMIG 2	EMIG 2A	EMIG 2B	EMIG 3
pH	3.21	3.65	6.68	--	--	7.42
AS	1100	<0.005	0.014	120	36	0.076
BA	350	<0.05	0.36	1800	440	1.3
CD	11	0.029	<0.005	2.0	1.9	<0.005
CR	35	0.024	<0.005	40	43	0.008
CU	160	0.82	0.01	54	23	0.015
HG	4.6	<0.0001	0.0003	3.2	<0.10	0.0001
PB	30	<0.005	<0.005	26	19	<0.005
SE	<5	0.005	<0.005	<5	<5	0.009
ZN	110	1.5	0.015	130	110	0.14

Parameter	EMIG 4	EMIG 4A	EMIG 6	EMIG 6A	EMIG 6B
pH	7.90	--	--	--	--
AS	120	--	48	67	74
BA	790	680	870	1400	260
CD	2.1	<0.5	1.1	1.2	1.0
CR	33	44	26	20	20
CU	87	38	120	31	28
HG	0.47	0.17	0.33	0.36	0.10
PB	20	18	25	25	23
SE	<5	<5	<5	<5	<5
ZN	120	130	160	130	130

- EMIG 1, 1B, 2, 2A, 2B: Represent samples of acid mine drainage, not in Emigrant Springs but in drainage channel upstream of Emigrant Springs, below the waste rock dump.
- EMIG 3: Represent a sample of the confluence of the acid drainage flow and Emigrant Spring.
- EMIG 4, 4A, 6, 6A, 6B: Represent solid samples from stream beds of Emigrant Springs, except pH in EMIG 4, which is liquid flow.
- If samples did not reveal concentrations above detection, the detection limit is shown.

Data Source: Rain Project Solution Collection and Return Design Report, 1990

APPENDIX 5-C

CHEMICAL ANALYSIS OF METEORIC WATER MOBILITY TEST FOR THE THIRD AND FOURTH QUARTERS OF 1990, AND THE FIRST QUARTER OF 1991

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APPENDIX 5-D

QUARTERLY MONITORING DATA FOR 1988 AND 1989 FOR SELECTED MONITORING WELLS AND THE SEEPAGE COLLECTION POND

Table 5-20. Monthly Average for Selected Sample Results, Rain Facility, 1988 [1]

Sample Location	Parameter	7/88	8/88	9/88	10/88	11/88	12/88
MW-2	pH	7.02/7.48	6.9/7.45	6.74	--	6.66/11.76	6.59/7.28
	EC	205	224	205	--	250	223
	Cyanide WAD	<.005 n=2	--	--	--	<.005 n=5	<.005 n=3 .12 n=1
	Cyanide Free	0.0 n=3	0.0 n=4	0.0 n=1	--	<.02 n=3 (.003,.033,.016) n=4	<.02 n=1 <.05 n=1 (<.005,1.7,.57) n=3
	Cyanide tot	--	--	--	--	--	--
MW-3	pH	--	--	--	6.12/6.7	5.04/6.77	6.0/7.3
	EC	--	--	--	692	785	538
	Cyanide WAD	--	--	--	(.006,.17,.064) n=3	(<.005,.093,.049) n=4	(.046,6.1,1.71) n=4 8.8 n=1
	Cyanide Free	--	--	--	<.02 n=1	<.02 n=2 (.018,.457,.15) n=4	5.3 n=1 7.0 n=1 (.134,4.8,1.57) n=3
	Cyanide tot	--	--	--	--	--	--

[1] 1. The pH values are given as Low/High for the month. 2. Electrical conductivity (EC) values are given as the average of reported values for the month. 3. Cyanide values are shown as (Low, High, Mean) for *each laboratory* reporting at least one result above test detection limits during that month. If analysis was performed with no concentrations above detection the test detection limit is shown. The "n" value on the right of a cell indicates the number of samples performed by a lab during that month.

Table 5-20. Monthly Average for Selected Sample Results, Rain Facility, 1988 (continued)

Sample Location	Parameter	7/88	8/88	9/88	10/88	11/88	12/88
MW-4	pH	--	--	--	--	5.61/6.51	6.03/6.18
	EC	--	--	--	--	1505	1233
	Cyanide WAD	--	--	--	--	(<.005,.005,.004) n=5	<.005 n=2 <.025 n=1
	Cyanide Free				--	0.0 n=3 <.02 n=3 <.005 n=4	<.02 n=1 <.025 n=1 (<.005,.115,.059) n=2
	Cyanide tot	--	--	--	--	--	--
MW-5	pH	--	--	--	6.0/6.8	6.71/7.39	--
	EC	--	--	--	724	752	--
	Cyanide WAD	--	--	--	(<.005,.03,.013) n=3	(<.005,.03,.017) n=4	--
	Cyanide Free	--	--	--	0.0 n=2 <.02 n=1	(<.02,.02,.017) n=3 (<.005,.083,.042) n=4	--
	Cyanide tot	--	--	--	--	--	--
RAIN SEEPAGE COLLECTION POND	pH	6.17	7.27/7.46	6.3	6.43/6.75	6.84/7.15	6.58/7.19
	EC	311	361	410	735	859	922
	Cyanide WAD	--	--	--	(1.5,11.6,5.6) n=3	(11,18,14.3) n=3	(20,45,30.3) n=3 63.0 n=1
	Cyanide Free	--	--	--	<.3 n=3	(11,18,13.7) n=3 (10,30,20) n=2	42.0 n=1 51.0 n=1 (18.5,39.0,28) n=3
	Cyanide tot	--	--	--	--	--	--

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 [2]

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
MW-2	pH	6.0/6.65	6.75/6.77	6.76/6.94	6.98/7.36			
	EC	229	218	204	170			
	Cyanide WAD	<.005 n=3 (.12,2.0,.75) n=3	(<.02,.3,.11) n=4	<.02 n=2	<.02 n=2			
	Cyanide Free	<.02 n=3 (.05,.16,.10) n=3 (<.005,.112,.04) n=3	(<.005,.041,.016) n=3	(<.015,.022,.011) n=4	<.015 n=2			
	Cyanide tot	--	(<.02,1.1,.31) n=4	<.02 n=4	<.02 n=2			
MW-2B	pH					8.41	7.62	7.83
	EC					1370	927	407
	Cyanide WAD					.1 n=1	<.02 n=1	<.02 n=1
	Cyanide Free					.059 n=1	--	--
	Cyanide tot					.10 n=1	<.02 n=1	.03 n=1
MW-3	pH	6.48/7.2	6.56/7.43	7.13/7.27	6.86/7.07	--	6.95	6.69
	EC	847	603	455	454	--	593	572
	Cyanide WAD	(9.3,13.4,11.1) n=3 (14,18,16) n=3	(.03,29.9,8.16) n=4	(.03,8.5,2.9) n=3	<.02 n=2	.09 n=1	<.02 n=1	<.02 n=1
	Cyanide Free	(8.9,13.1,10.6) n=3 (11,16,13.7) n=3 (10.8,11.9,34.5) n=3	(.161,24.4,6.67) n=5	(.026,12.54,6.5) n=3	<.015 n=2	<.015 n=1	<.015 n=1	--
	Cyanide tot	--	(.1,34.8,10.15) n=4	(.05,9.7,3.3) n=3	(.04,.29,.17) n=2	.07 n=1	.1 n=1	--

[2] 1. The pH values are given as Low/High for the month. 2. Electrical conductivity (EC) values are given as the average of reported values for the month. 3. Cyanide values are shown as (Low, High, Mean) for *each laboratory* reporting at least one result above test detection limits during that month. If analysis was performed with no concentrations above detection then the test detection limit is shown. The "n" value on the right of a cell indicates the number of samples performed by a lab during that month.

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 (continued)

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
MW-4	pH	6.09/6.51	5.51/6.55	6.21/6.42	6.30/6.34	6.31	6.56	6.55
	EC	1252	798	782	758	805	820	719
	Cyanide WAD	<.005 n=3 (.11,.18,.147) n=3	(<.02,.09,.03) n=4	<.02 n=4	<.02 n=2	<.02 n=1	<.02 n=1	<.02 n=1
	Cyanide Free	<.02 n=3 (<.01,.07,.045) n=3 (<.015,.08,048) n=3	(<.015,.007,.006) n=4	<.015 n=4	<.015 n=2	<.015 n=1	--	--
	Cyanide tot	--	(<.02,.08,.03) n=4	(<.02,.08,.03) n=4	<.02 n=2	<.02 n=1	<.02 n=1	<.02 n=1
MW-5	pH	--	6.82	7.14/7.48	6.84/7.0	6.61	6.69	6.58
	EC	--	545	344	385	443	491	542
	Cyanide WAD	--	(<.02,.08,.028) n=5	(<.02,.03,.017) n=3	<.02 n=2	<.02 n=1	<.02 n=1	<.02 n=1
	Cyanide Free	--	(.015,.021,.01) n=4	<.015 n=3	<.015 n=2	<.015 n=1	--	--
	Cyanide tot	--	(.03,.3,.116) n=5	(<.02,.1,.05) n=3	<.02 n=2	<.02 n=1	<.02 n=1	<.02 n=1
MW-6		Dry	--	Dry	Dry	Dry	Dry	Dry
MW-7	pH	--	9.95/10.53	8.57/10.3	Abandoned			
	EC	--	382	489	--	--	--	--
	Cyanide WAD	--	(.01,.08,.063) n=4	(.08,.13,.103) n=3	--	--	--	--
	Cyanide Free	--	(<.015,.03,.016) n=4	<.015 n=3	--	--	--	--
	Cyanide tot	--	(.2,1.0,.416) n=4	(.28,.43,.337) n=3	--	--	--	--

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 (continued)

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
MW-8			Dry	Dry	Dry	Abandoned		
MW-9	pH	--	9.02	8.36/9.2	8.73	Abandoned		
	EC	--	468	665	978			
	Cyanide WAD	--	<.02 n=2	(<.02,.03,.015) n=4	<.02 n=1			
	Cyanide Free	--	(.007,.029,.018) n=2	<.015 n=2	<.015 n=2			
	Cyanide tot	--	(<.02,.03,.02) n=2	(<.02,.04,.023) n=4	.08 n=1			
MW-10	pH	--	7.41/8.12	7.54/7.61	7.44	Abandoned		
	EC	--	806	540	531			
	Cyanide WAD	--	(6.7,21.8,13.7) n=3	(.09,.24,.158) n=4	.03 n=1			
	Cyanide Free	--	(8.06,15.5,12.8) n=4	(.07,.444,.183) n=4	<.015 n=1			
	Cyanide tot	--	(9.9,22.4,16.2) n=3	(.25,1.1,.46) n=4	.14 n=1			
MW-11	pH	--	9.66	8.58/8.78	8.5	Abandoned		
	EC	--	424	377	372			
	Cyanide WAD	--	(.06,.2,.12) n=3	(<.02,.07,.03) n=3	<.02 n=1			
	Cyanide Free	--	(.013,.172,.07) n=3	(<.015,.029,.015) n=3	<.015 n=1			
	Cyanide tot	--	(.01,.03,.23) n=3	(.02,.13,.06) n=3	<.02 n=1			

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 (continued)

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
MW-12	pH		Dry	8.62	8.85	Abandoned		
	EC			357	370			
	Cyanide WAD			<.02 n=1	<.02 n=1			
	Cyanide Free			<.015 n=1	<.015 n=1			
	Cyanide tot			<.02 n=1	<.02 n=1			
MW-13			Dry	Dry	Dry	Abandoned		
MW-14	pH		--	7.69	--	7.60	7.76	8.25
	EC		--	330	--	197	192	177
	Cyanide WAD		--	<.02 n=1	<.02 n=1	<.02 n=1	<.02 n=1	<.02 n=1
	Cyanide Free		--	--	<.015 n=1	<.015 n=1	--	--
	Cyanide tot		<.02 n=1	<.02 n=1	<.02 n=1	<.02 n=1	<.02 n=1	<.02 n=1
MW-15	pH		Dry	Dry	Dry	Abandoned		
MW-16	pH		8.3	7.7	7.73/7.93	7.68	7.75	Dry
	EC		1530	832	566	468	535	
	Cyanide WAD		<.02 n=1	<.02 n=2	<.02 n=1	<.02 n=1	<.02 n=1	
	Cyanide Free		<.015 n=1	<.015 n=2	<.015 n=2	<.015 n=1	--	
	Cyanide tot		<.02 n=1	<.02 n=2	<.02 n=1	<.02 n=1	<.02 n=1	

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 (continued)

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
MW-17			--	--	Dry	Abandoned		
MW-18	pH		--	Dry	7.63	Abandoned		
	EC		--		294			
	Cyanide WAD		--		<.02 n=1			
	Cyanide Free		--		<.015 n=1			
	Cyanide tot		--		<.02 n=1			
MW-19	pH		--	--	Dry	Dry	7.9	Dry
	EC		--	--			652	
	Cyanide WAD		--	--			<.02 n=1	
	Cyanide Free		--	--			--	
	Cyanide tot		--	--			<.02 n=1	
MW-20	pH		--	--	Dry	Dry	Dry	Dry
MW-21	pH		--	--	7.8	7.43	7.85	7.3
	EC		--	--	725	851	769	601
	Cyanide WAD		--	--	--	<.02 n=1	<.02 n=1	<.02 n=1
	Cyanide Free		--	--	<.015 n=1	.085 n=1	--	--
	Cyanide tot		--	--	--	<.02 n=1	<.02 n=1	<.02 n=1

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 (continued)

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
MW-22	pH		--	--	Dry	Dry	Dry	Dry
MW-23	pH		--	--	8.65	8.06	7.77	Dry
	EC		--	--	2760	1811	1290	
	Cyanide WAD		--	--	--	<.02 n=1	<.02 n=1	
	Cyanide Free		--	--	<.015 n=1	<.02 n=1	--	
	Cyanide tot		--	--	--	<.02 n=1	<.02 n=1	
RAIN SEEPAGE COLLEC-TION POND	pH	6.73/7.18	7.41/7.62	7.4/7.8	7.5/7.57	7.39	7.02	7.5
	EC	968	783	669	772	842	801	901
	Cyanide WAD	(15,34,22.7) n=3 (24,34,30.7) n=3	(2.7,20.8,12.1) n=3	(1.5,6.6,4.8) n=3	2.0 n=1	2.2 n=1	2.12 n=1	3.73 n=1
	Cyanide Free	(15,27,20) n=3 (27,37,32) n=3 (23,36,277) n=3	(6.9,20.2,14.6) n=4	(1.2,7.2,4.8) n=3	(1.6,2.5,2.0) n=2	--	--	--
	Cyanide tot	--	(6.9,18.5,12.9) n=3	(2.4,7.8,5.6) n=3	2.0 n=1	4.0 n=1	2.76 n=1	4.74 n=1
RAIN SEEPAGE COLLEC-TION POND TRENCH DRAIN	pH	Dry	--	5.81/7.89	6.92/7.44	7.62	--	--
	EC		--	333	452	639	--	--
	Cyanide WAD		--	(<.02,.09,.05) n=3	(.02,.05,.035) n=3	.03 n=1	--	--
	Cyanide Free		--	(<.015,.276,.11) n=3	(<.015,.093,.036) n=3	--	--	--
	Cyanide tot		--	(.1,.21,.14) n=3	(.02,.12,.07) n=2	.09 n=1	--	--

Table 5-21. Monthly Average for Selected Sample Results, Rain Facility, 1989 (continued)

Sample Location	Parameter	1/89	2/89	3/89	4/89	5/89	6/89	7/89
RAIN BACK-GROUND SPRING 1	pH		--	6.75	--			
	EC		--	128	--			
	Cyanide WAD		--	<.02 n=1	--			
	Cyanide Free		--	.003 n=1	--			
	Cyanide tot		--	<.02 n=1	--			

APPENDIX 5-E

**COMMENTS SUBMITTED BY NEWMONT GOLD COMPANY
ON DRAFT SITE VISIT REPORT**

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APPENDIX 5-F

EPA RESPONSE TO COMMENTS SUBMITTED BY NEWMONT GOLD COMPANY

EPA Response to Comments Submitted by
Newmont Gold Company on Draft Site Visit Report

EPA has revised the report to address all of the comments made by Newmont Gold Company in a letter dated May 15, 1992 (see Appendix E). In some cases, EPA made changes to wording suggested by Newmont, either for brevity, in order to attribute the changes to Newmont, or to enhance clarity.

It should be noted that Newmont states in its comments that it does not believe that RCRA §3001 or §3007 provided EPA with the authority to conduct the site visit and document review at the Rain facility. EPA disagrees. Notwithstanding its position on the authority under which the site visit and data collection occurred, Newmont cooperated with EPA before, during, and after the site visit. Newmont's cooperation is appreciated.