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IRON MOUNTAIN MINES, INC.

Executive Offices

1900 POINT WEST WAY, SUITE 102
SACRAMENTO, CA 95815
916-922-8821

APA DEVELOPMENTS

IRON MOUNTAIN PROPERTIES
IRON MOUNTAIN INVESTMENT CO.
IRON MOUNTAIN COPPER COMPANY

April 4, 1985

2
4/4/85

Mr. Thomas Mix
U.S. Environmental Protection Agency
Toxics & Waste Management Division
215 Fremont Street
San Francisco, CA 94105

Dear Mr. Mix:

Enclosed is a copy of our In Situ Leaching of Massive Sulfide and Metal Recovery Project Proposal for your information and review.

Very truly yours,

IRON MOUNTAIN MINES, INC.

T. W. Arman
President

TWA/kd

Enclosure

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IN SITU LEACHING OF MASSIVE SULFIDE AND METAL RECOVERY PROJECT PROPOSAL

IRON MOUNTAIN MINES

SHASTA COUNTY, CALIFORNIA

MARCH 1985

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

This proposal presents a concept for a unique mining and metals recovery operation at Iron Mountain Mines, Shasta County, California, which involves (1) the in situ leaching of a massive sulfide ore body to extract copper, zinc, iron and precious metals, and (2) the recovery of the base metals as industrial and agricultural chemicals.

The mine has large proven ore reserves and its previously worked open pit and underground stopes are readily convertible to a solution mining operation with low capital investment. Plant sites, mill buildings, electrical power and water are already available, and good roads provide easy access to the plant site which is located about 15 miles northwest of Redding, California, and Interstate I-5. Thus, site development costs would also be minimal.

A hydrometallurgical plant for which a flowsheet has been developed and tested (for a similar metals recovery process) would recover 12 tons per day of copper and zinc as agricultural chemicals and 50 tons of iron salts for agricultural and water treatment use. The process flowsheet also has the flexibility to treat various types of copper scrap and metallic industrial waste sludges.

A preliminary feasibility study indicates that a capital cost of $15 to $20 million would be required. The operation has a projected life of 15 to 50 years, with a favorable return on capital investment. Basic design and construction could be completed within 18 months.

Preliminary test work would be necessary to optimize the in situ leaching technique, develop basic design criteria and prepare the required environmental reports. This would take six to nine months.

This project provides an opportunity to develop a low cost mining operation while simultaneously eliminating a long-standing environmental mine water problem.

Iron Mountain Mines, Inc. believes that this project presents the opportunity for a highly profitable, multi-metal in-situ mining operation at a much lower capital cost than any other mining operation of equal production capacity.

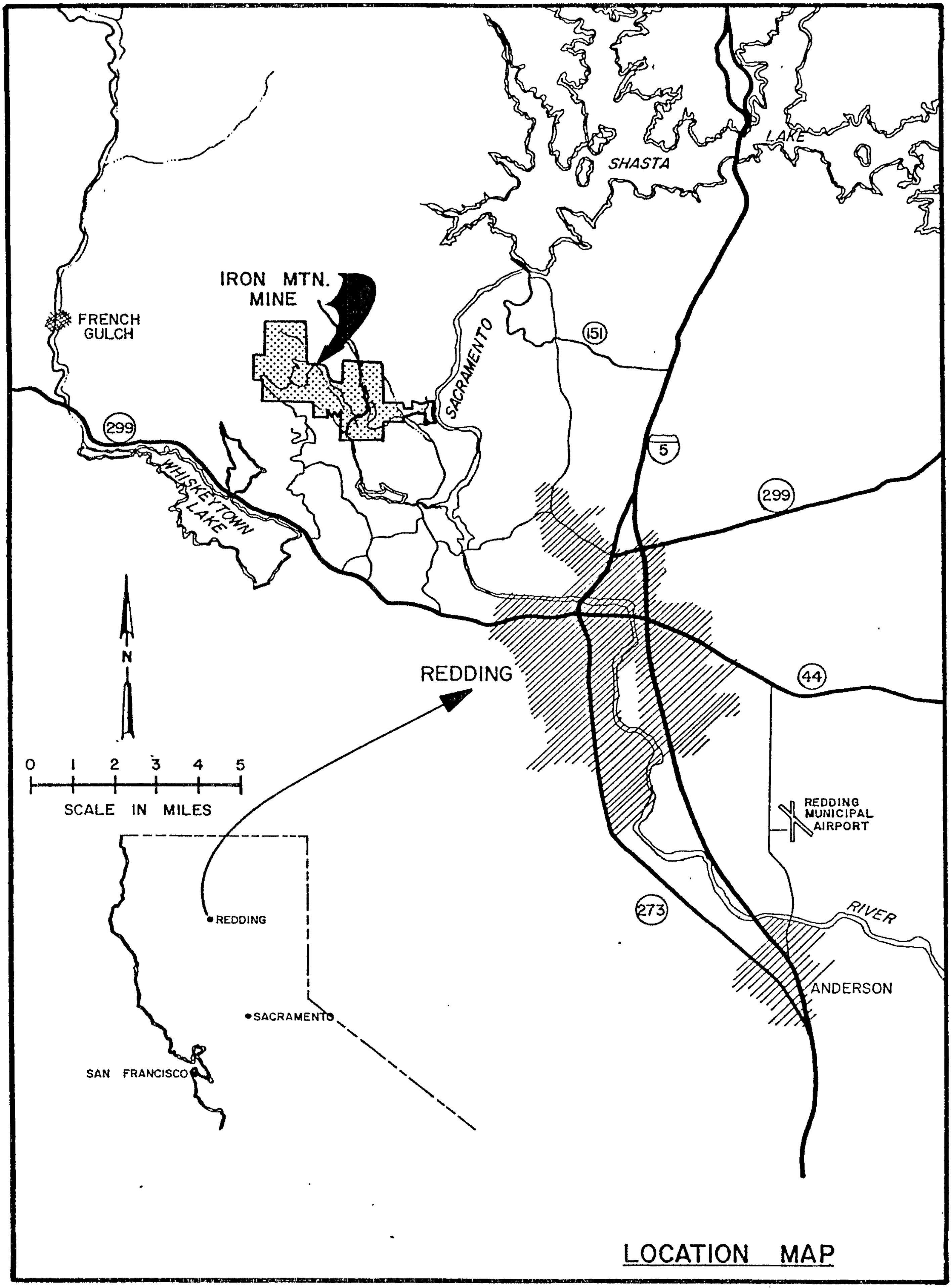
PROPOSED IN SITU LEACHING OF MASSIVE SULFIDE AND METAL RECOVERY PROJECT AT IRON MOUNTAIN MINES

INTRODUCTION

The Iron Mountain Mines, Inc. (IMMI), ore deposits are located in Shasta County, 15 miles northwest of Redding, California, in the Klamath Mountains (Figures 1 and 2). The proven ore deposits discussed in this report are 12,000,000 tons of massive sulfides, containing large reserves of copper, zinc, gold, silver, platinum, iron, and sulfur for which mining and processing plans are currently being developed. Several massive sulfide ore deposits comprise the Iron Mountain Mines complex. Even though the massive sulfides yielded 6,300,000 tons of ore containing 232,500 tons of copper, 198,000 tons of zinc, 76,000 ounces of gold, and 1,700,000 ounces of silver between 1879 and 1967, two thirds of the proven tonnage remains.

These massive sulfide ore bodies are generating a natural flow of mine water which emerges from two mine portals. This flow varies in volume, depending on rainfall, and contains economically significant concentrations of copper, zinc, and various precious metals. The mine water also contains large amounts of iron. This water has been treated for the past 50 years at the mine site to remove copper. The treatment process continues today using scrap iron to precipitate the copper from 25 to 500 gallons per minute of mine water solutions.

IMMI has been working in close collaboration with its consultants during the past several years to help resolve the mine water discharge problem in a way which would not impede the economical development of the valuable mineral reserves on the property. On the basis of the mining and metallurgical data available from IMMI records, a



LOCATION MAP

FIGURE 2

MASSIVE SULPHIDE AND GOSSAN DEPOSITS

Aerial View of Mine and Plant Site

conceptual approach to a viable, low-cost metal recovery method (solution mining) with the concurrent resolution of the mine water discharge problem has been developed. This plan emphasizes the importance of a viable mining operation integrated with a low-cost mine water pollution abatement plan which can be implemented within a very short time at minimum expense, and which will not interfere with total mineral recovery. IMMI's consultants have extensive experience in mining, minerals beneficiation, hydrometallurgy, environmental science and engineering which enable them to contribute ideas for innovative mining and recovery processes. Thus, they have the potential for making the development of this unusual massive sulfide ore body an economic success.

This following text presents a concept for a new type of mining operation which incorporates the most recent, low-cost mining techniques with the flexibility of a hydrometallurgical plant for recovering high value metal products. It also outlines a scope of work for a feasibility study to determine the best approach to bringing the mine into production. Emphasis would be placed upon a staged development to minimize capital commitment while eliminating the mine drainage water problem almost immediately.

SOLUTION MINING PLAN

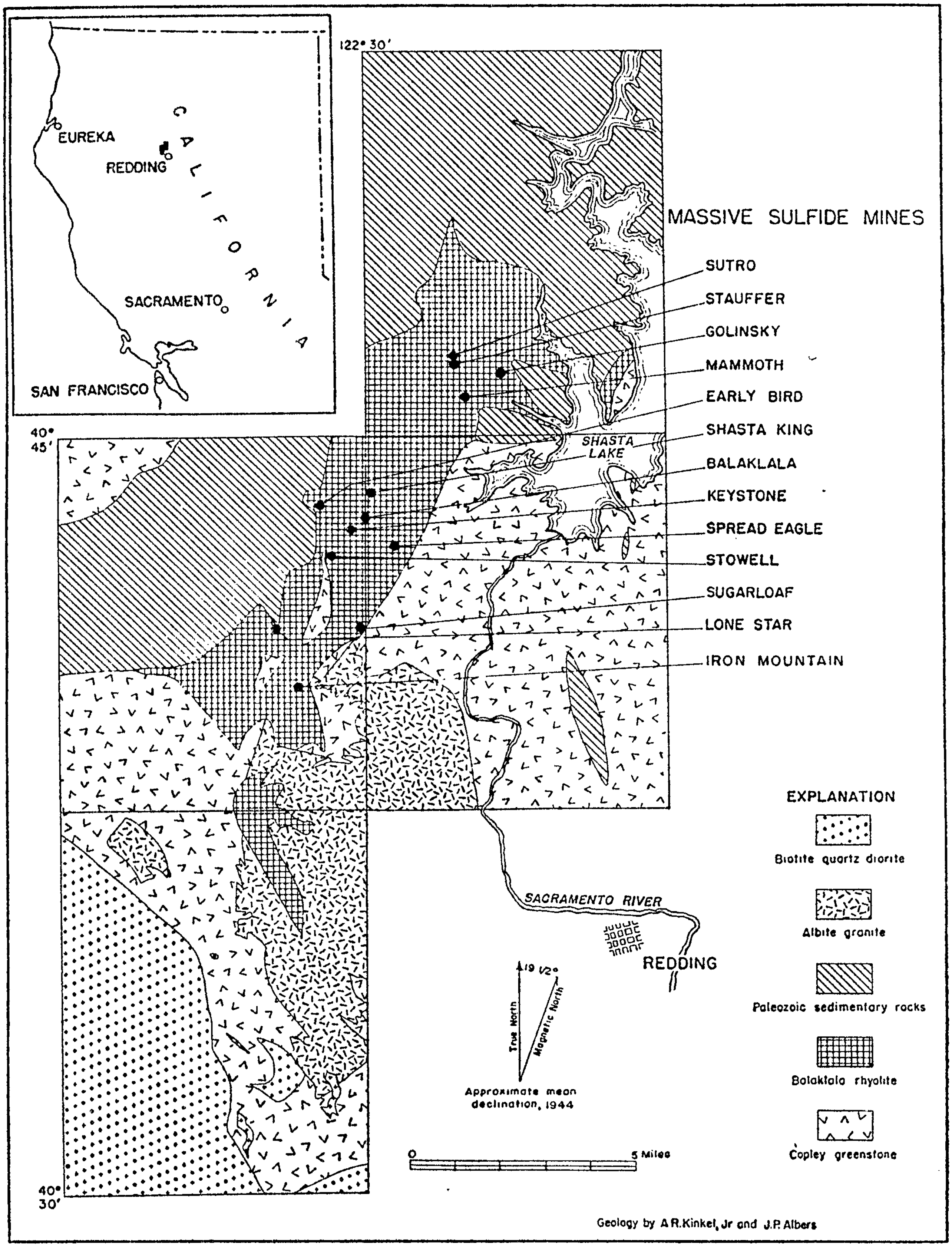
The most logical alternative for resolving the mine water problem is to convert the ore deposits into a solution mining operation. This would involve the engineered augmentation of the natural leaching processes that are presently operating by: (1) increasing flow rates through the formations by various techniques, particularly by recycling the mine water; (2) enhancing the base metal extraction rates of the circulating solutions through the use of in situ and/or heap leaching techniques; and (3) reducing the volume of water discharged from the mine site and attaining a "zero heavy metal discharge" situation within EPA's or State's minimum requirements.

The massive sulfide deposits in the West Shasta Copper-Zinc District (Figure 3) were formed millions of years ago on the bottom of an ocean floor in a saucer-shape or a natural collection basin. The main deposits slope in a natural, downward direction, creating a natural flow path for the circulating solutions. Fractures in the main ore deposits appear to be above this collection basin, therefore, the leach solutions should be well controlled.

A starter plant would be designed to produce a minimum of 6 tons per day of electrolytic grade copper and 24 tons per day of copper sulfate (see Table I for values). Copper recovery would be based upon the use of low cost electrical energy which could be available from the 3.5 megawatt hydroelectric plant anticipated to be constructed on IMMI's adjoining property, or from existing Pacific Gas & Electric Company (PG&E) power lines already on the property.

Iron, the major heavy metal contaminant in the mine water, would be recovered as saleable products (jarosite or ferrous sulfate) rather than being converted into large volumes of worthless dilute sludge which create expensive disposal or storage problems and induce high chemical treatment costs.

Zinc (about 12 tons per day) and cadmium would be recovered as saleable salts or sludges. Residual metals, such as cobalt, aluminum and magnesium, plus final traces of iron, zinc, copper and cadmium, would be removed by neutralization from any waters discharged from the property.



Map showing location of the West Shasta copper-zinc district and its generalized geologic setting.

A list of probable products is shown in Table I.

Features of a solution mining system for the profitable recovery of copper, zinc, cobalt, cadmium, aluminum, iron and precious metals with simultaneous resolution of the mine water discharge problem are outlined below:

1. The process would augment the present water flow through the ore body by recycling the re-acidified mine water (copper SX raffinate) and using additional water to increase the flow to at least 2,000 gallons per minute. Flow rates could be increased in the future, depending upon the metal production rates desired.

2. By employing heap leaching in the open pit (Brick Flat) with subsequent in situ leaching of the ore body by the heap leach liquors, the copper content of the leach solution would be increased to at least one gram per liter. This leaching process would be an engineered enhancement of the natural leachability of the ore body as indicated by the high metallic content of the present mine drainage waters. In situ mining techniques would be essentially identical to those presently being used successfully in other parts of the world under similar circumstances.

3. Metallic copper would be recovered as electrolytic copper using the electric power from PG&E already on the property or power to be generated by the new 3.5 megawatt hydroelectric plant scheduled for construction on adjoining property. Six to 12 tons of copper could be produced each day. Copper will also be recovered as copper sulfate.

4. The high concentrations of iron in the mine water are used initially as an oxidizing agent (ferric ion) to enhance the dissolution of the copper minerals. Any excess

build up of iron in the circulating liquors would be recovered from a bleed stream in the form of saleable iron products such as acidulated ammonium jarosite (a soil conditioner), ferric chloride (a water treatment chemical), ore-grade iron oxide, or ferrous sulfate (agricultural grade).

Since cadmium + zinc "metals" are the current concern, the question of how effective this new proven technology is in removing these compounds is raised

5. By continuously recycling solutions through the ore body, zinc and cadmium can also be recovered from a bleed stream (by new solvent extraction technology) in the form of saleable agricultural salts or smelter sludges. It is expected that a minimum of 12 tons per day of zinc would be recovered in the form of agricultural grade products.

6. About 90 percent of the process water containing regenerated sulfuric acid from the copper recovery circuit would be recycled to the mine leaching circuit. A ten percent bleed stream circuit would produce the iron, zinc, cadmium and precious metal by-products (see Table 1).

7. The barren bleed stream would be neutralized with lime to produce a water quality suitable for discharge or return to the mining circuit. In heap leaching and in situ leaching operations, water losses due to evaporation and mechanical losses can be as high as 30 percent of the circulating flow; thus, it is possible that all water could be returned to the system and a "no heavy metal discharge" operation would be attained.

8. Since solution mining is the cheapest type of mining and is especially suited for small, low-grade ore bodies, this operation has the potential for being highly profitable and would require minimum capital investment.

9. The solution mining approach presents the opportunity for completely eliminating the heavy metals in the present mine water either by the attainment of a

non-discharge operation or by controlled release of a small volume of an acceptable water, the low treatment costs for which would be borne by the mining operation.

10. The alternative of using conventional, open-pit mining and milling would be much more expensive and, in the light of past operating experience, does not appear to be economically viable. This is due to the fact that the copper and zinc sulfide minerals are extremely fine grains disseminated in massive pyrite. Previous milling records indicate that copper concentrates (probably high in zinc) attained maximum grades of 15 to 20 percent copper. Zinc recovery in low-grade zinc concentrates (49 percent zinc) was only about 50 percent. These types of concentrates are not sufficient to be profitable when shipped long distances to a smelter.

PROJECT POTENTIAL

The project consists of two major sections -- the in situ-heap leaching operation and an inorganic chemical manufacturing plant designed to produce copper, zinc, and iron salts for industrial and agricultural purposes. In contrast to the typical mining and refining plant that produces low value prime metals for no specific market, this operation will produce high value metal salts for specific markets. Due to its location and ready accessibility by both road and rail line, this plant will have a significant advantage over competitive sources (largely in the East) insofar as freight rates are concerned where these can often be more than the cost of the product.

The plant will also have a small research and development laboratory wherein work will be continuously directed to the development of new products and improved operational techniques.

Some of the specific areas into which the project will have the potential to expand are:

1. The production of additional copper salts such as basic copper carbonate and cuprous chloride (another agricultural chemical used on fruits).

2. The production of additional iron salts such as

   - modified ferrous sulfide (pyrite) - for specialized markets.

   - ferric sulfate - water treatment chemical.

   - ferric chloride - solution and salts - a water treatment chemical.

   - iron oxide - large tonnages exist in the gossan deposit at the mine site and can be upgraded to saleable products by flotation.

   - magnetite - an appreciable tonnage is available at the surface and can easily be upgraded to saleable products for heavy media and other specific industrial applications.

3. The production of additional zinc salts such as basic zinc carbonate, zinc oxide and zinc chloride.

4. With the addition of a surface leaching facility, the plant would be capable of treating:

- o low-cost mixed scrap (iron, copper, zinc, nickel, and aluminum) for which there are very few treatment plants in the United States.

- o low-grade electronic precious metal scrap and circuit boards.

- o metallic sludges and solutions which are industrial waste products, particularly from the electronics and electroplating industries. Most of these are now classified by state and Federal environmental agencies as hazardous wastes for which very few disposal sites exist.

The IMMI plant could treat these waste products to recover saleable metal products and charge a significant processing fee for making the conversions. The environmental agencies would welcome such a facility as an answer to one of their critical waste disposal dilemmas.

PROCESS ECONOMICS

Estimates of the profitability of the proposed in situ mining and hydrometallurgical plant operation indicate that a $15 to $20 million investment would have a favorable B:C ratio over normal amortization periods.

PROJECT LIFE

If the projected plans materialize for having a versatile plant capable of treating a wide variety of metallic raw materials in addition to the metal values from the mine itself, the project life could be extended indefinitely depending upon the amount of outside raw materials used.

Since copper in the massive sulfide is the lowest tonnage material and would probably have the slowest extraction rate, plant economics are based upon copper recovery. In situ operations have demonstrated that recoveries of at least 25% can be expected. On this basis, the minimum period of operation at full production can be calculated as follows:

246,000 tons Cu x .25 = 61,500 tons recoverable copper

$$\frac{61{,}500 \text{ tons Cu}}{12 \text{ tons/day extracted} \times 330 \text{ days/year}} = 15.5 \text{ years operation}$$

A 25% factor for copper recovery under normal leaching operations has been used as a basis of economic projection in this presentation; however, the Iron Mountain Mines massive sulfide project is unique in many ways and the application of an Economic Simulation Model as developed through the U.S. Bureau of Mines (referenced in Appendix D) will no doubt show a more favorable economic projection for Iron Mountain Mines when compared to a normal leaching operation because:

1. The percentage of copper removed is shown to increase with depth of ore independent of ore grade. The Iron Mountain Mines ore bodies are up to 500 feet thick.

2. The grade of the Iron Mountain ore bodies is considerably higher than the average leach operation.

3. The normal cost of acid for the preparation of leaching fluids is reduced because the leachate (sulfuric acid) is produced naturally and no acid consuming gangue minerals are present.

4. The geological and physical factors of massive sulfides are very favorable in that the ore bodies are well defined, are well-contained for recovery of fluids, are relatively close to the surface, and are not of a disseminated nature. (Figure 4.)

5. Multiple by-product recovery, in addition to copper, produces a much expanded economic base.

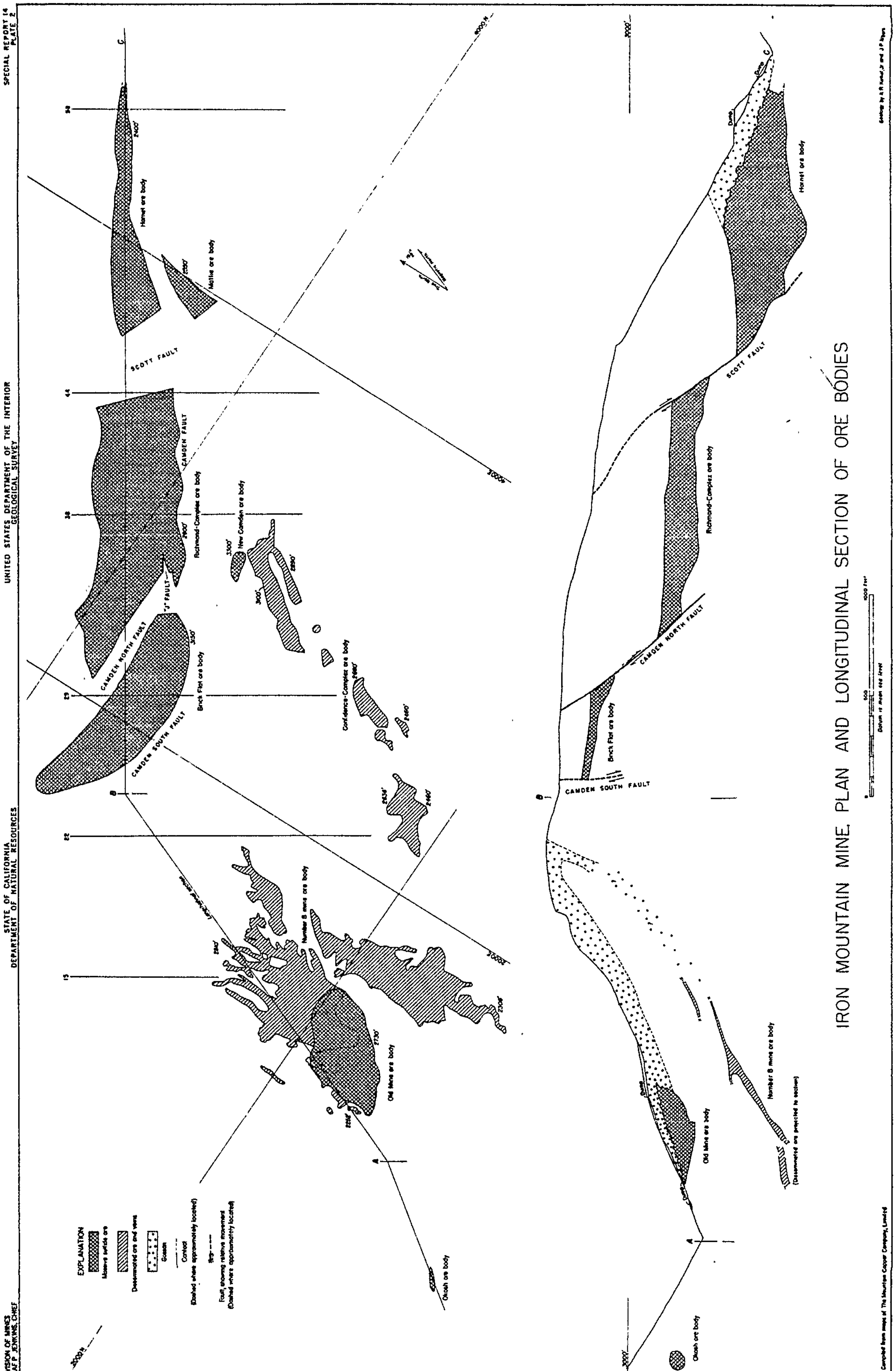
6. The availability of voluminous records covering drilling, production, assays, mapping, and historical data will eliminate much of the normal pre-in situ leaching development costs.

The above factors when included in the development of an Economic Simulation Model for Iron Mountain Mines' massive sulfide ore bodies should reflect an overall longer operating life as well as an improved comparative financial analysis.

HISTORY OF IN SITU LEACHING

The basic operation proposed is in situ leaching of Richmond and Hornet workings with surface heap leaching of surface ore in the Brick Flat open pit. In situ leaching is not a new concept, but its application has developed most in recent years because it is the cheapest form of mining available. Past experience and state-of-the-art applications are summarized in a recent publication by the U.S. Bureau of Mines, IC 8961, "In Situ

FIGURE 4



DIVISION OF MINES
OLAF P. JENKINS, CHIEF
STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SPECIAL REPORT 14
PLATE 2
EXPLANATION
Massive sulfide ore
Disseminated ore and veins
Gossan
Contact
(Dashed where approximately located)
Fault, showing relative movement
(Dashed where approximately located)
CAMDEN NORTH FAULT
CAMDEN SOUTH FAULT
"J" FAULT
CAMDEN FAULT
SCOTT FAULT
Old Mine ore body
Number 8 mine ore body
Okosh ore body
Brick Flat ore body
Richmond-Complex ore body
New Camden ore body
Confidence-Complex ore body
Hornet ore body
Mattie ore body
(Disseminated ore projected to section)
IRON MOUNTAIN MINE PLAN AND LONGITUDINAL SECTION OF ORE BODIES
Datum is mean sea level
Compiled from maps of The Mountain Copper Company, Limited

Copper Leaching in the United States," by J. K. Ahlness and M. G. Pojar (1983) (referenced in Appendix D). The following excerpts are taken from that publication: ?

Summary

one chance in three of IMM succeeding?

"To date, there have been at least 24 sites in the United States where in situ copper mining production or research has taken place. Three have been commercial operations with ore body preparation (blasting), seven have been commercial operations in old mine workings, and 14 were experimental sites. Of these experimental sites, only eight reached the leach solution application stage.

"Ore bodies that are too low grade or small to be mined by conventional methods have potential for in situ mining because of the relatively low capital and production costs involved. The method is not normally considered for other deposits because of its relatively low recovery. Leaching of old mine workings such as block caves, backfilled slopes, and open pits, is often an economic method for recovering additional copper when conventionally minable reserves have been depleted. Experimental work has typically been done on a small scale to determine the feasibility of commercial operations, however, several of the Bureau of Mines experiments were directed specifically at ore fragmentation by blasting and were not leached.

"At present the only two active, commercial, in situ copper operations in the United States (Copper Queen Branch and Miami mine) involve leaching of old mine workings. The Lakeshore mine is the only active experimental site, and Noranda is planning to go commercial in the near future.

"*In situ* copper mining activities have been shut down for several reasons, with the most common one being economic (low copper prices, excessive ore preparation costs, etc.). Other causes of shutdowns have been expansion of open pit operations into leach areas, environmental concerns, technical difficulties (inability to contain solutions, low pregnant solution grade, etc.), and one operation was closed when the lease agreement was not renewed.

"Many of the companies plan to resume leaching programs when copper economics improve, and Ranchers is considering a plan to blast and leach *in situ* the remaining ore in the Bluebird open pit. *In situ* mining will become much more attractive and play an increasingly important role in future copper production as conventional mining costs increase and ore grades decrease."

A summary of operating parameters for several commercial *in situ* copper mining plants compiled by the Bureau of Mines are shown in the charts on the following pages.

FACTORS FAVORING *IN SITU* LEACHING AT IRON MOUNTAIN MINES

1. The ore body is a partially mined massive sulfide deposit with essentially no acid consuming gangue material and almost 100 percent leachable surface area at any particle size.

IN SITU COPPER MINING OPERATING DATA

Commercial operations

Operation		Big Mike Mine	Old Reliable Mine	Zonia mine	Burro Mountain Branch
Location		Winnemucca, NV	Copper Creek near Mammoth, AZ	Kirkland, AZ	Tyrone, NM
Host rock		Greenstone, chert, argillite, some limestone	Volcanic agglomerate, primarily andesite	Shale, andesite	Quartz monzonite, porphyry, granite
Copper minerals:					
Principal		Cuprite, tenorite, chalcopyrite	Chalcocite, chalcopyrite, malachite, chrysocolla	Chrysocolla	Chalcocite
Minor		Not available	Chalcanthite, azurite, native	Azurite, malachite, tenorite	Chrysocolla, covellite, chalcopyrite, bornite, azurite, malachite
Average ore grade	pct	1.18	0.84	0.2 (blasted portion of deposit only)	Not available
Ore preparation		Blasted pit walls and bottom with angled and vertical blastholes terraced	Coyote blast of hillside using old and new underground mine workings, terraced	Blasted pit walls and bottom with vertical blastholes (3 separate blasts)	None, leached block-caved areas
Area involved	ft²	122,000	245,000	390,000 (1st blast only)	Not available
Maximum depth	ft	160	500	240	Do.
Quantity of material	T	640,000	4 million	6,830,000	Do.
Average fragment size	in	9	8.5	12-14	Do.
Leach solution		Dilute H_2SO_4	Dilute H_2SO_4	Dilute H_2SO_4	Water
pH		1.6-2.0	1.7-2.3	2.0-2.2	Not available
Solution application		Rainbird sprinklers	Rainbird sprinklers 1st leach, sprinklers and 5 injection holes 50 ft deep 2d leach	Rainbird sprinklers	Do.
Flow rate	gpm	175-200	1,000-1,100 (1st leach), 600-700 (2d leach)	500-1,000	Do.
Solution recovery		Recovery well (16-in diam, 180 ft deep)	Flowed from hillside at base of rubble and collected in basin	Recovery well in pit bottom (10-in diam, 100 ft deep)	Underground workings
Water table		110 ft below postblast surface	1.8 ft below lowest adit	Preblast pit bottom	Not available
Pregnant solution copper content	gpL	Initial 2.0, then dropped to 1.0 1st leach, 0.8 2d leach	Initially 1.8, then dropped to 0.6 at 1st shutdown, 0.4 at 2d shutdown	2.0-0.8	Do.
Type of copper recovery		Precipitation on scrap iron	Precipitation on scrap iron	Precipitation on scrap iron	Precipitation on scrap iron
Consumption, lb/lb Cu:					
Acid (H_2SO_4)		1.5	5.0	15	Not applicable
Iron		1.75	2.4	2.1	Not available
Copper production	lb/d	5,000 (maximum)	20,000 (design capacity)	5,000 (maximum)	Do.
Employees		6-8	15	25	Do.
Active dates		1973-74, 1978-79	July 1972-September 1974, August 1979-January 1981	April 1973-early 1975	May 1941-1949

Operation		Butte Montana mines	Copper Queen Branch	Inspiration mine	Miami mine
Location		Butte, MT	Bisbee, AZ	Claypool, AZ	Miami, AZ
Host rock		Quartz monzonite	Sacramento quartz porphyry	Granite schist	Pinal Schist
Copper minerals:					
Principal		Chalcopyrite, chalcocite	Chalcocite	Azurite, malachite, chrysocolla	Chalcocite
Minor		Bornite, azurite, malachite	Azurite, malachite	Chalcopyrite, chalcocite, cuprite, covellite	Covellite, malachite, azurite, bornite, chalcopyrite, chrysocolla, cuprite, native
Average ore grade	pct	0.8	0.29	0.5	0.88 original ore body, caved stopes unknown
Ore preparation		None, leached backfilled stopes	None, leached open pit and underground workings	None, leached block-caved stopes	Glory hole over block-caved area terraced
Area involved	ft²	Not available	Not available	130,000-175,000	5 million
Maximum depth	ft	5,000	1,800	850	1,000 (600 ft of caved material)
Quantity of material	T	Not available	Not available	Not available	Not available
Average fragment size	in	Do.	Do.	Do.	Do.
Leach solution		Mine water with a small amount of H_2SO_4	Mine water	Dilute H_2SO_4	Dilute H_2SO_4
pH		2.1	7	Not available	1.5
Solution application		Old access to stopes or injection holes (3-in diam, 10 ft apart)	Rotating head sprinklers	Injection holes (12-in diam, 250-300 ft deep)	Perforated pipe sprays and injection holes (6-in diam, average depth 195 ft)
Flow rate	gpm	700 (maximum)	500	190-560 (yearly averages)	3,070
Solution recovery		Underground workings	Underground workings on 1,800-ft level	Underground workings on 850-ft level	Dams in drifts on 1,000-ft level
Water table		Maintained at lowest working level	Maintained at 3,100-ft level	Above water table	Not available
Pregnant solution copper content	gpL	0.50-0.75	0.6 (mixed in situ and dump solutions)	1.8 initially, 0.7 last year of operation	0.835 (1981)
Type of copper recovery		Precipitation on scrap iron	Precipitation on scrap iron	Precipitation on scrap iron	Precipitation on scrap iron until 1975, presently SX-EW
Consumption, lb/lb Cu:					
Acid (H_2SO_4)		Not available	Not applicable	Not available	3.2 (4.0 pre-1976)
Iron		Do.	Not available	2.5	2.0 pre-1976
Copper production	lb/d	33,000 (average)	5,800 (maximum in situ production)	5,200 (average)	30,000-35,000 design capacity
Employees		15-30 (underground crew only)	2 (pit plumbing needs only)	1-4 (solution application only)	30-35
Active dates		1930's-1984	1975 to present	1967-74	1942 to present

Commercial operations—Continued

Operation		Ohio Copper Co mine	Ray mine
Location		Bingham Canyon, UT	Ray, AZ
Host rock		Quartzite with quartz monzonite intrusion	Schist and diabase
Copper minerals:			
Principal		Chalcocite	Chalcocite
Minor		Malachite, azurite	Chrysocolla, malachite, azurite
Average ore grade	pct	0 3	1 0
Ore preparation		None, leached block-caved material	None, leached block-caved material
Area involved	ft²	840,000	435,000
Maximum depth	ft	1,900 (1,200 ft of caved material)	300
Quantity of material	T	38 million	Not available
Average fragment size	in	4	Do
Leach solution		Creek and mine water	Fresh water
pH		Not available	7
Solution application		150 ft launder with 2 in-diam holes, moved on a regular pattern	Rotating sprinklers
Flow rate	gpm	1,200 1,400	340 500
Solution recovery		Tunnel on 1,900 ft level	Concrete dams in underground drifts
Water table		Above water table	Above water table
Pregnant solution copper content	gpL	2 02	9 23
Type of copper recovery		Precipitation on scrap iron	Precipitation on scrap iron
Consumption, lb/lb Cu:			
Acid (H_2SO_4)		Not applicable	Not applicable
Iron		1 0	1 15
Copper production	lb/d	20,000 (average)	20,000 (average)
Employees		Not available	Not available
Active dates		Started in 1922, now part of Bingham Canyon open pit	Started in 1937, now part of Ray open pit

Experimental operations involving leach solution application

		Consolidated Copper Co mine
Location		Ely, NV
Host rock		Shear zone in monzonite
Copper minerals:		
Principal		Sulfide
Minor		Very little oxide
Average ore grade	pct	0 3
Ore preparation		None, leached block-caved material
Area involved	ft²	Not available
Maximum depth	ft	360
Quantity of material	T	Not available
Average fragment size	in	Do
Leach solution		Water
pH		Not available
Solution application		Do
Flow rate	gpl	Do
Solution recovery		Underground workings
Water table		Not available
Pregnant solution copper content	gpL	1 0
Type of copper recovery		Precipitation on scrap iron
Consumption, lb/lb Cu:		
Acid (H_2SO_4)		Not applicable
Iron		Not available
Copper production	lb/d	Do
Employees		Do
Active dates		Started in 1925, closure date unknown

Experimental operations involving leach solution application—Continued

Operation		Emerald Isle mine: Pit blast leach	Emerald Isle mine: Pit bottom leach	Kimbley pit	Mezler mine
Location		Kingman, AZ	Kingman, AZ	Ruth, NV	Clifton, AZ.
Host rock		Gila Conglomerate.	Gila Conglomerate	Limey sediment intruded by argillic porphyry	Porphyry.
Copper minerals:					
Principal		Chrysocolla	Chrysocolla	Chalcocite.	Sulfide.
Minor		Dioptase, tenorite, and cuprite	Dioptase, tenorite, and cuprite.	Not available.	Oxide
Average ore grade	pct	1 0	1 0	0 32	0 38
Ore preparation		Blasted pit bottom with vertical blastholes	None, leached pit bottom	None.	None, drifts driven for access
Area involved	ft²	4 420	26,125	1,200	Not available
Maximum depth	ft	50	40	265 (165-ft ore thickness)	260
Quantity of material	T	15,000	100,000	12,000	Not available
Average fragment size	in	Not available	Not available	Not available.	Not applicable.
Leach solution		Dilute H_2SO_4.	Dilute H_2SO_4	Dilute H_2SO_4.	Water from mine sump
pH		1 18	1 10	Not available.	Not available
Solution application		Perforated pipes	Perforated pipes	Drift injection (through fractures and drill holes).	Flooded drifts
Flow rate	gpm	63 5	116	50 injected, 0 2 recovered.	Not available
Solution recovery		Recovery well (11-in diam 50 ft deep, cased with 10 in-diam PVC pipe perforated in bottom 20 ft.)	7 recovery wells (12-in diam, 50 ft apart, 180 ft deep)	Recovery well (265 ft deep, at low point in limestone basin under test area).	Drifts.
Water table		5 ft below pit bottom	5 ft below pit bottom	170 ft below surface.	Between 3d and 4th mine levels
Pregnant solution copper content	gpL	0.59	0 85	0 08-0 17 (0.15 average)	0 2-0 60
Type of copper recovery		Precipitation on scrap iron	Precipitation on scrap iron	Not available.	Precipitation on scrap iron
Consumption, lb/lb Cu:					
Acid (H_2SO_4)		15.0	10 0	Do	Not applicable
Iron		4 7	2 75	Do	Not available
Copper production	lb/d	245 (average)	745 (average)	Do	Do
Employees		Not available.	Not available.	Do.	3 (solution handling only)
Active dates		March 1974-June 1974.	December 1974-June 1975.	1970-71 (pilot leach test only)	April 1906-about 1909.

Experimental operations involving leach solution application—Continued

Operation		Mountain City mine	Van Dyke deposit
Location		Mountain City, NV	Miami, AZ
Host rock		Phyllite and quartzite lenses in shale	Pinal Schist
Copper minerals			
Principal		Chalcocite	Chrysocolla
Minor		Chalcopyrite, cuprite, malachite, chrysocolla, azurite, native.	Azurite, malachite
Average ore grade	pct	0.93-1.10	0.5
Ore preparation		Blockcaving	Wells drilled and hydrofraced
Area involved	ft²	54,400	1st test involved 2 wells 75 ft apart, 2d test 10,000 (5-spot pattern)
Maximum depth	ft	400	1st test 1,000, 2d test 1,200
Quantity of material	T	793,000	Not available
Average fragment size	in	Not available	Do
Leach solution		Dilute H_2SO_4	Dilute H_2SO_4.
pH		Not available	Not available
Solution application		Injection wells (25-ft centers, 150-200 ft deep, 2-in-diam PVC casing)	Injection well (4-in diam)
Flow rate	gpm	Grossly variable, 0-25 per hole.	Not available (1:1 ratio between injection and production)
Solution recovery		Drift on 400-ft level that drained to mine sump on 450-ft level	4-in-diam recovery well (1 for 1st test, 4 for 2d test)
Water table		Above water table	Below water table
Pregnant solution copper content	gpL	0.5-0.6	Not available
Type of copper recovery		Precipitation on scrap iron	SX-EW (neighboring plants)
Consumption, lb/lb Cu:			
Acid (H_2SO_4)		Not available.	Not available
Iron		Do	Not applicable.
Copper production	lb/d	4,800 (average)	Not available
Employees		Not available.	Do
Active dates		March 1974-December 1974.	January 1976-October 1980

2. Voluminous assay data, mining records and mine maps are available pertaining to the geology, drilling, sampling, mining and milling operations at the property. These data consist of records of previous mining companies and a recent exploratory drilling program (1982-1983), plus U. S. Geological Survey studies of the massive sulfide ore deposit. The U.S.G.S. plans to complete a new report in 1985 covering their continuing studies during the period of 1977 through 1984.

3. A basic, natural, in situ leaching system is presently working and generating metal-bearing solutions at flow-rates with seasonal variations of 25 to 2,000 gpm. Natural drainage appears to be quantitatively collected at the bottom of the basin-shaped ore body and drains through accessible old mine portals to convenient discharge points. This indicates the probability of high solution recovery.

4. Previous mining operations developed a large open pit, surrounded by mineable ore, located above old workings which have large open stopes on four levels. Tracer tests have indicated that drainage from the pit flows through the old workings and exits at the old portals. This situation indicates excellent potential for the rapid initiation of a low cost in situ operation similar to the operation of Pinto Valley Copper Corporation at Miami, Arizona.

5. Excellent facilities are available at the mine site, including a good paved (county) access road, a large plant site for buildings, electrical power lines, railroad spur, aerial tramway (if needed), and good water supply. The plant site under study is about 15 miles from Redding, California, and major truck route I-5.

6. Return circulating lines from the plant site would be less than one mile long with a lift of about 400 feet from the upper plant site and 800 feet if the lower site is used.

In summary, the above elements indicate the following favorable conditions:

- o no exploratory drilling and sampling program is needed to establish ore reserves;
- o no costly site development and property access work is required;
- o no costly solution injection and collection systems need to be engineered and installed for plant startup;
- o there are indications that the ore is readily leachable.

But, won't the success of the operation ultimately be driven by the market for copper
— there is no mention as to how favorable this market looks for in-situ leaching @ IMM

ESTIMATED PROJECT COSTS

IMMI's estimates of capital and operating costs are presented in Tables 1 and 2. Supporting data for other basic elements in the profitability calculations are not presented in this report. Calculations not included in this report indicate that this project has high economic viability. All assumptions and bases used are indicated below:

Production Rate - as shown in Table 3

Plant Cost - $15,000,000

Plant Operating Time - 330 days per year

Water Treatment Operation - 365 days per year

Working Capital - $2,500,000

Project Life - 15 to 50 years

Site Closure Plan + related cost

TABLE I

CAPITAL COST ESTIMATE

(1985 Dollars)

1.	In Situ Leaching Operation	$ 1,000,000
2.	Copper Solvent Extraction (includes general area preparation, installation of services, pipelines and pumps, and indirect costs (21.6%))	6,690,000
3.	Copper Electrowinning and Copper Sulfate Production	3,000,000
4.	Jarosite and Copperas Facilities	300,000
5.	Zinc Solvent Extraction (proven?)	1,670,000
6.	Cadmium Recovery (by what methods)	50,000
7.	Waste Water Treatment	300,000
8.	Contingency (10%)	1,500,000
		$ 14,510,000

TABLE 2

PROJECTED DAILY OPERATING COSTS

(1985 Dollars)

		Daily Costs
Raw Materials		
Ammonia		$ 300
Oxygen		75
Organic Solvent		720
Sulfuric Acid		680
Salaried Labor and Fringe Benefits		2,000
Supervision and Administration		700
Electricity		1,600
Fuel Oil		3,000
Maintenance (3% c.c./year)		1,400
Laboratory Supplies		100
Depreciation (15-year straight line)		3,030
Indirect Costs (3% c.c./year)		1,363
	TOTAL	$14,968

TABLE 3

Daily Production Schedule

Product	Base Metal Content	Production Rate
Copper Cathode	6 tons	6 TPD
Copper Sulfate	6 tons	24 TPD
Zinc Sulfate	12 tons	33.3 TPD
Ferrous Sulfate (copperas)	6 tons	30 TPD
Gypsum	--	80 TPD
Jarosite	6 tons	20 TPD
Alum	--	50 TPD
Gold	3.5 t.o.	3.5 t.o.
Platinum	7 t.o.	7 t.o.
Silver	7 t.o.	7 t.o.

ENVIRONMENTAL ASPECTS

IMMI is required by the California Water Quality Control Board, Central Valley Region, and EPA to eliminate heavy metal discharges in local streams by treating the present mine water effluent.

The recirculation concept presented here could be implemented immediately, or as soon as financing is secured, by the installation of pumps and a temporary plastic pipeline sized to handle present discharges. This would create a "zero heavy metal discharge" condition which could be operative until a permanent facility is constructed. This return line would also initiate the study of recirculation within the ore body to determine the nature of soluble metal changes in the recycled water.

The EPA is currently sponsoring a $700,000+ environmental study at Iron Mountain Mines, a major portion of which is directed to a detailed investigation of the hydrology of the area. The Water Quality Control Board has indicated to Iron Mountain Mine, Inc.'s consultants that they will accept the results of this study as the equivalent of an environmental impact report (EIR) for any new operation applying for water permits. What?

IMMI believes that the proposed operation will be able to attain a permanent "zero heavy metal discharge" condition without requiring any costly waste water treatment methods and equipment. A zero (heavy metal) water discharge would eliminate the present environmental concerns to the California Water Quality Control Board and EPA.

But will site operations meet WQ objectives @ Keswick?

PRELIMINARY STUDIES

Before the proposed solution mining project could be designed, a preliminary study must be made at the property to determine optimum operating conditions from which design criteria could be developed. The overall objective of this study would be to examine alternative ways and means of integrating the recovery of the mineral values present in the IMMI ore deposits with the treatment of any mine water discharges in order to yield a maximum profit.

This feasibility study should consist of the following basic work elements:

1. Investigate various methods to augment the volume and copper content of the present mine water flow such as:

   - o Recycling of raffinate from the solvent extraction circuit through old mine workings to dissolve larger quantities of copper and zinc salts and enhance natural bacterial oxidation processes.

   - o Setting up experimental heap leaching column tests to treat crushed ore and old sulfide tailings presently existing on the property to obtain design criteria for an in situ leaching process.

   - o Investigating the possibility of tapping into enriched underground copper solutions by spotting locations for pilot wells.

2. Conduct an investigation of all facilities and surface materials at the plant site and establish a sampling program to confirm earlier sampling results.

3. Establish a full-scale program for testing various ore body solution extraction and solution enrichment (in situ) processes based upon pilot plant test work. This would be a coordinated effort involving mining engineers, geologists, and IMMI metallurgical engineering consultants.

4. Confirm a final conceptual flowsheet for a hydrometallurgical process plant possibly consisting of activated carbon units, solvent extraction and electrowinning facilities, similar to Figure A-1 and A-2. The flowsheet would be designed to recover copper, zinc, cadmium, iron, aluminum, gold, silver, platinum, and cobalt in the form of saleable salts. The plant would use all of the mine water as process water, almost all of which will be recycled underground for in situ leaching or to heap leaching. Essentially, no mine water would be discharged during the first year of operation. Subsequently, any water discharge from the plant would be neutralized to meet IMMI's present NPDES discharge limits. The first target would be to build recycle water up to a flow rate of 2,000 gpm. Any overflow can be pumped to IMMI's timber properties for irrigation and to supply micronutrients to the forest.

Most of the flowsheet development work has been completed by IMMI consultants as indicated in this report.

5. Review all environmental considerations applicable to the IMMI property to ensure that the proposed process facilities meet all current requirements of the present IMMI NPDES permit. + downstream WQ standards.

6. Prepare confirmatory operating and capital cost estimates for the conceptual hydrometallurgical process plant for recovering 12 tons per day of pure copper, 12 tons

of zinc, and the estimated quantities of precious metals, cobalt, cadmium, aluminum, and iron salts. A conceptual block flowsheet is shown in Figure A-1 in Appendix A.

7. Prepare a feasibility report to summarize all of the data generated during the study.

APPENDIX A

Metals Recovery Plant Operations

A schematic of the conceptual solution mining process is shown in Figures A-1. The major unit operations involved are the following:

1. Solvent extraction for copper and zinc recovery.

2. Electrowinning for producing cathode grade copper and sulfuric acid.

3. Evaporating crystallizers for zinc, iron and copper salt recovery.

4. Hot precipitation for the recovery of iron as jarosite (a basic iron sulfate).

5. Leaching and evaporation for the recovery of alum and gypsum.

Cadmium ?

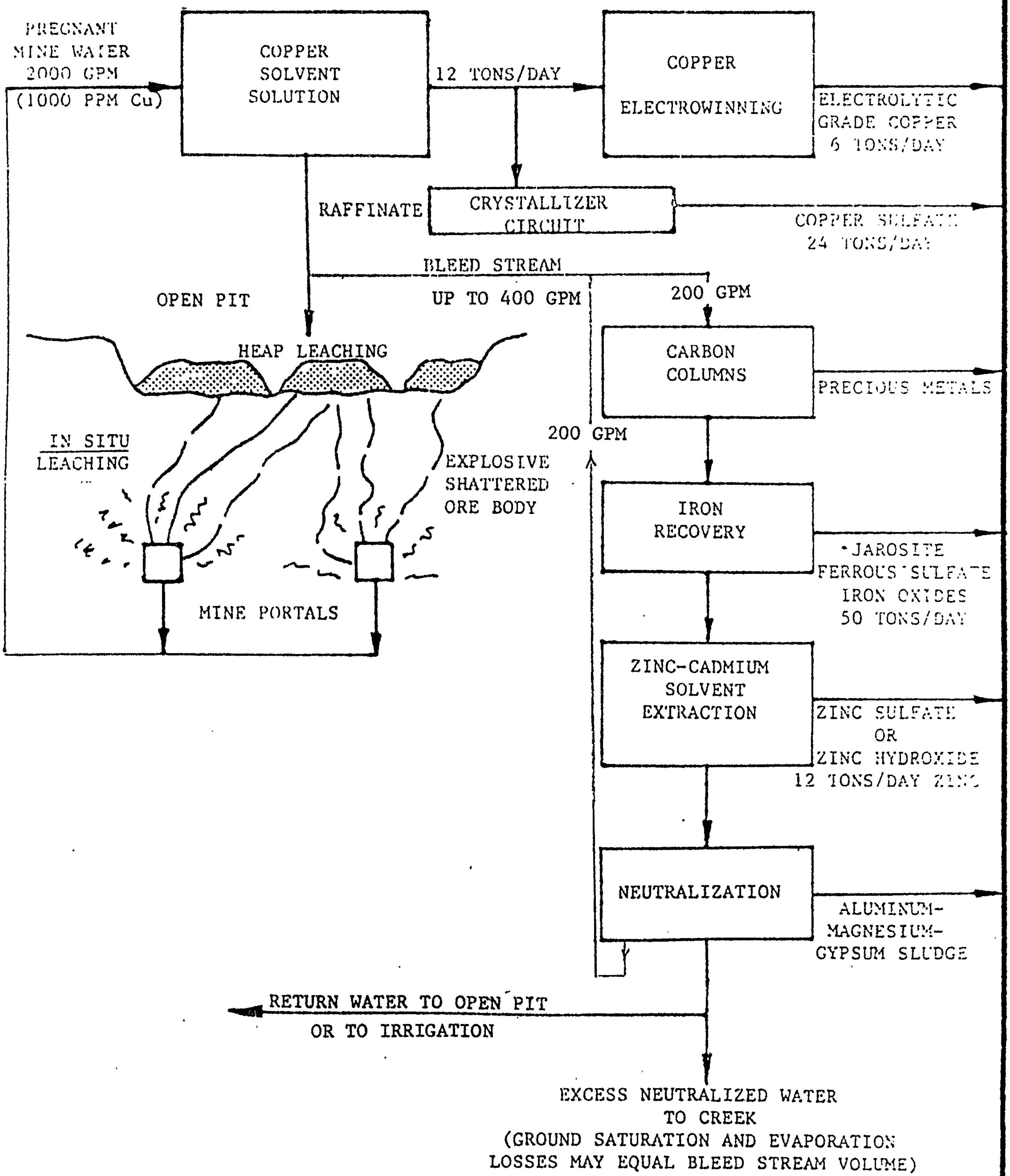
All of these are proven technologies which are currently in operation in many parts of the world. A typical copper solvent extraction flowsheet is shown in Figure A-2. This plant was built for Inspiration Copper Company in Arizona by Davy McKee within the past five years to treat dump leach liquors. It is currently in full operation (~5000 gpm).

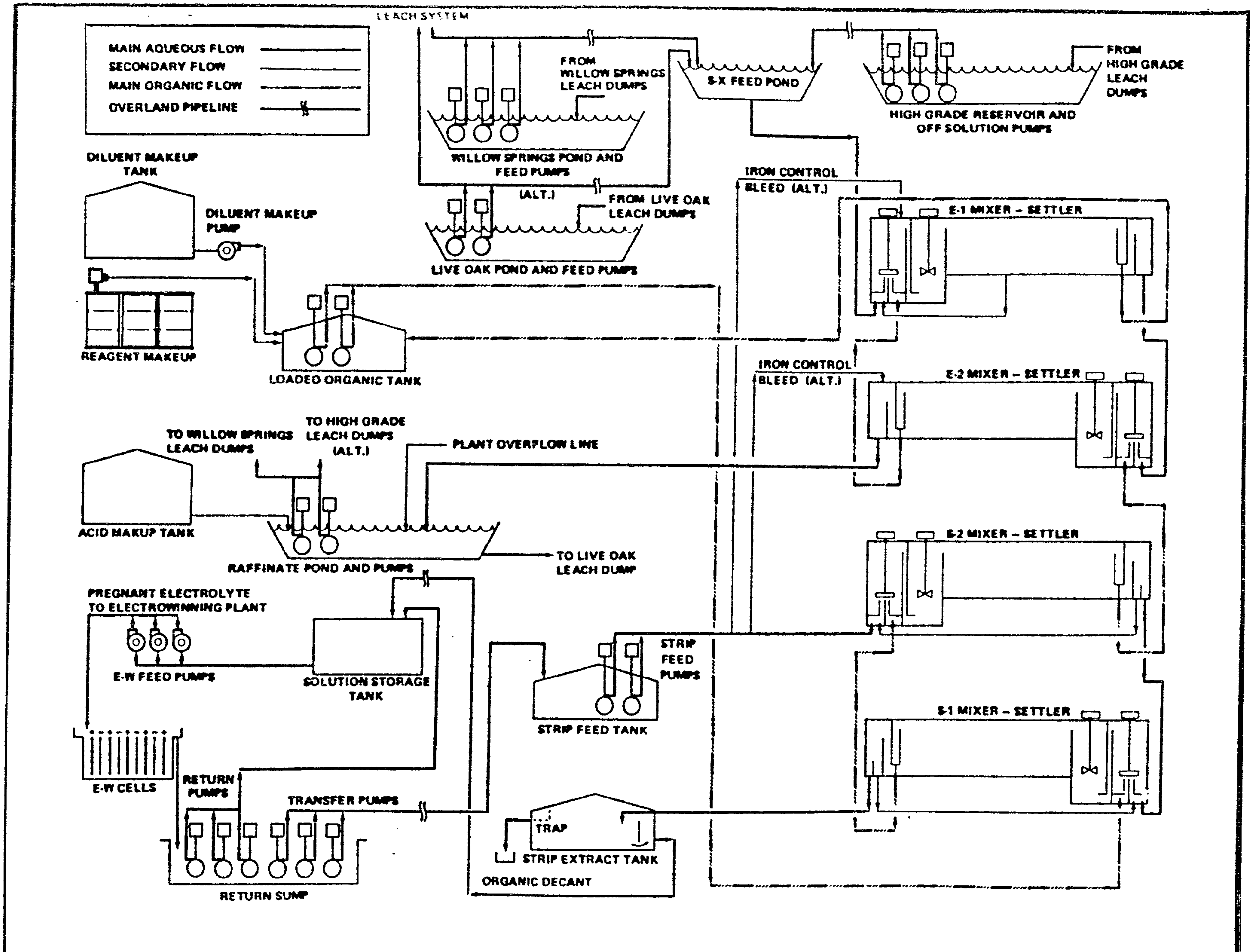
Figure A-3 is a sketch of a mixer-settler unit, which is the key element in a solvent extraction circuit.

The Davy McKee Corporation (San Ramon, California) has built at least ten copper solvent extraction plants within the past ten years, all of of which are in operation. A

FIGURE A-1

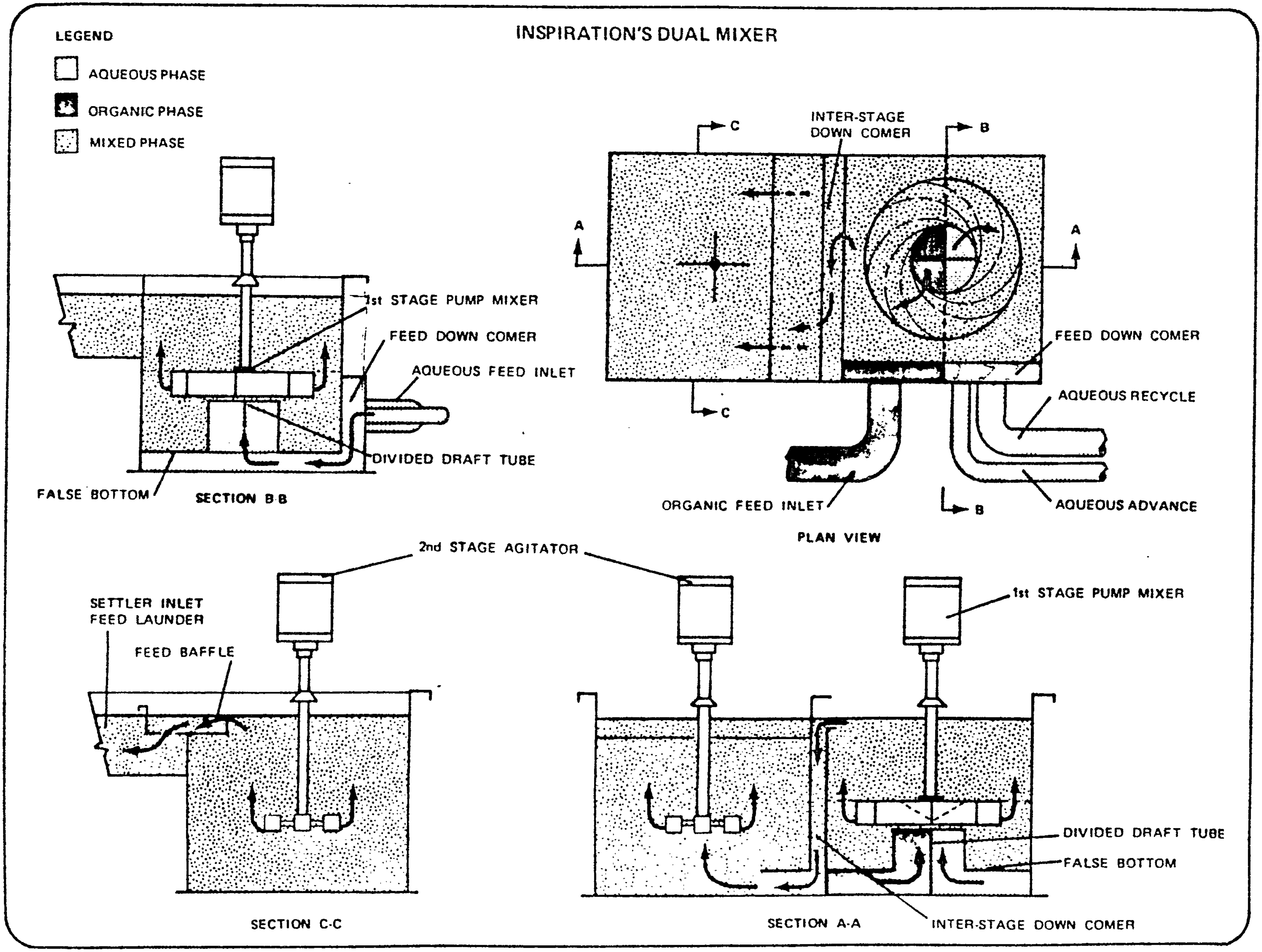
CONCEPTUAL SOLUTION MINING PROCESS
FOR IRON MOUNTAIN MINES





TYPICAL COPPER SOLVENT EXTRACTION PLANT

INSPIRATION'S DUAL MIXER



plant recently constructed at El Teniente in Chile is for treating 5000 gpm of acid mine water containing one to two grams per liter of copper. Davy McKee also has exclusive licensing rights for the latest zinc solvent extraction technology (zincex and Comprex processes).

Three plants in Spain are currently using this technology to treat ores very similar to those at Iron Mountain Mines.

Jarosite precipitation is standard technology in the zinc hydrometallurgy field and is being used very successfully in large plants in Australia. Cyprus Mines and Duval Corporation have also used jarosite precipitation in their copper chloride leaching plants.

The major principle of operation of the plant is to treat 2000 gpm of water from in situ leaching in the preimary copper solvent extraction plant, with a recycle of 1800 gpm to the mine. A bleed stream of 200 gpm goes to the metal salts recovery plant for treatment. The waste water produced by this plant will go to a water treatment plant using a ferric sulfate coagulation-lime softening process plus activated carbon to produce a discharge water for irrigation purposes (see Appendix B for discussion of water quality).

This conceptual flowsheet has been reviewed by the Process Development Laboratory technical staff of Utah International, and by the Process Development Section of Davy McKee Corporation. Both have confirmed that the flowsheet is sound and that all of the unit operations are standard technology. Over the past several months, Iron Mountain Mines, Inc. has been negotiating with major mining and engineering firms to joint venture this project. Iron Mountain Mines, Inc. has been offered a contract by Davy McKee Corporation to confirm a final fasibility report. Iron

Mountain Mines, Inc. will be negotiating with Davy McKee Corporation to provide all mining services including engineering, construction, operation and management.

Detailed information on the proposed process and its unit operations can be furnished on request.

APPENDIX B

IMMI Mine Water Management Plan

In addition to the commercial recovery of metal and metal salt products from the enriched recycled mine water, the management plan has two major objectives.

1. To treat all of the acid mine water from the five major sources to remove greater than 95% of the Cu, Cd, Fe and Zn. All treated water will be kept on the property for irrigation purposes.

2. To either eliminate or significantly diminish the flows and seeps from most other sources (dumps and tailing piles) by use of diversion ditches or by transferring the source material to the open pit where it will be within the water control system.

A schematic of the water management system is shown in Figure B-1. It is composed of two sub-systems; one on the Boulder Creek side and one in the Slickrock Creek basin; each having an independent water treatment plant.

Boulder Creek Section

The Boulder Creek section contains three major sources -- Richmond portal, Lawson portal, and Brick Flat Pit Bypass, and is the area in which the in situ leaching will be done. This section can operate independently except during the two months of high flow when it functions as a storage area for excess water from the Slickrock side. The main features of this section for water control purposes are:

1. The Richmond and Lawson portals are sealed to withstand the pressure required by a 20- to 30-foot deep storage pool in the Richmond open slope area. The seal wall will have two stainless steel outlet pipes with control valves on each to permit flow control at a constant rate of 2000 gpm or complete cut-off in case of a power failure or plant shut-down. The seal wall will also have an access pressure door to permit entrance to the mine area for maintenance and inspection.

2. The storage pool has an area of 17 acres and a working level of five feet to insure a constant feed rate to the plant. During the high flow months (December and January), the pool will store about 165 acre feet (600 gpm). This will raise the level of the pool by about ten feet.

3. During the low flow period (July through November), stored water will be removed from the pool at a rate of about 230 gpm until the normal working level is attained.

4. The total storage capacity of the pool at 30-foot depth is 511 acre fee (166 million gallons), which will provide emergency storage volume at 1000 gpm for 115 days. Thus, the storage volume of just a small portion of the old Richmond workings provides adequate surge capacity to accommodate any adverse set of circumstances and prevent inadvertent discharge of untreated water to the local streams.

Slickrock Section

This section contains the two major sources, Old No. 8 and Big Seep, which has the largest volume but the lowest concentrations of metals. The elements of this system are:

1. A divided surge pond of 12 acre feet capacity in which the two source flows can be stored separately. This pond will provide at least three days of emergency storage at maximum flow (900 gpm) in the event of a power failure or pump station shut down.

2. A pumping station with a maximum capacity of 500 gpm which can be operated intermittently to lift the water up to the Brick Flat open pit.

3. The present copper cementation plant for intermittent emergency use.

4. A 500 gpm water treatment plant (lime neutralization) which will produce an effluent of irrigation water quality. This water will be used for irrigation of timberland at an application rate of two inches per week.

Seasonal Water Balances

The interaction of the two systems varies with the seasonal fluctuations of the water flows. Three flow conditions (normal, high, and low flow periods) are shown in the water balances in Figures B-2, B-3, and B-4.

The key control for the system is the portal valve which maintains a constant flow of 2000 gpm to the copper solvent extraction plant.

During the normal flow period, 166 gpm of water from the Slickrock system is pumped into the open pit and no water is stored within the Richmond mine. Treated water for irrigation is discharged from the two treatment plants at 190 and 134 gpm for application to 72 acres of timberland.

zinc + cadmium removal?

During the high flow period, the Slickrock water treatment plant is operated at full capacity (500 gpm) and about 400 gpm of Slickrock area water is pumped to the open pit. Six hundred gallons per minute is stored for a period of 60 days in the Richmond storage pool. The Boulder water treatment plant operates at a constant rate of 200 gpm and discharges 134 gpm of treated water.

During low flow periods, only 65 gpm of Old No. 8 water is pumped into the open pit and the Slickrock water treatment plant output is reduced to 106 gpm. In the Boulder Creek system, 230 gpm will be withdrawn from the Richmond storage pool to maintain the constant flow of 2000 gpm to the copper recovery plant. The water treatment plant will operate at a constant 200 gpm.

The metals recovery plant operates year-round at a feed rate of 2000 gpm, with a recycle rate from the primary copper solvent extraction plant of 1800 gpm and a bleed stream of 200 gpm.

The neutralized sludge from the Boulder water treatment plant will be processed to recover alum and gypsum. Under special conditions, some sludge may be pumped underground to old workings outside the in situ area.

Sludge from the Slickrock plant (about one-tenth the Boulder sludge volume) will go to underground disposal.

Discharge Water Quality

The water treatment plants will be ferric sulfate coagulation-lime softening systems with activated carbon polishing units if required. It is anticipated that about 98% removal of iron, copper, cadmium and zinc can be obtained based upon EPA studies. The quality of water discharged for irrigation should equal or exceed the EPA heavy metal discharge criteria for Metal Finishing and Electroplating Point Sources (40 CFR Part 413-1984) which are shown in Table B-1.

TABLE B-1

DISCHARGE CRITERIA FOR ELECTROPLATERS AND METAL FINISHERS

EPA LIMITS - mg/l

	Metal Finishers		Electroplaters	
	Maximum	Average	Maximum	Average
Cd	0.69	0.26	1.2	0.7
Cu	2.77	1.71	4.5	2.7
Zn	2.61	1.48	4.2	2.6
(Fe)	(7.0)	(2.0)	(7.0)	(2.0)

The discharged water will have a pH of 8 to 9 and be saturated with calcium sulfate (e.g., 500 mg/l Ca and 1500 mg/l SO_4.

Table 2 shows the heavy metal content of the maximum flows from the two water treatment plants in terms of pounds per day. If these flows were accidentally diverted into the local creeks, the impact on the Sacramento River at low flow (5000 cfs) is shown in Column C. These figures indicate that the effect of accidental diversions to the Sacramento River would be negligible under worst case conditions.

TABLE B-2

MAXIMUM DAILY METAL DISCHARGE FROM
WATER TREATMENT PLANTS

(700 GPM TOTAL)

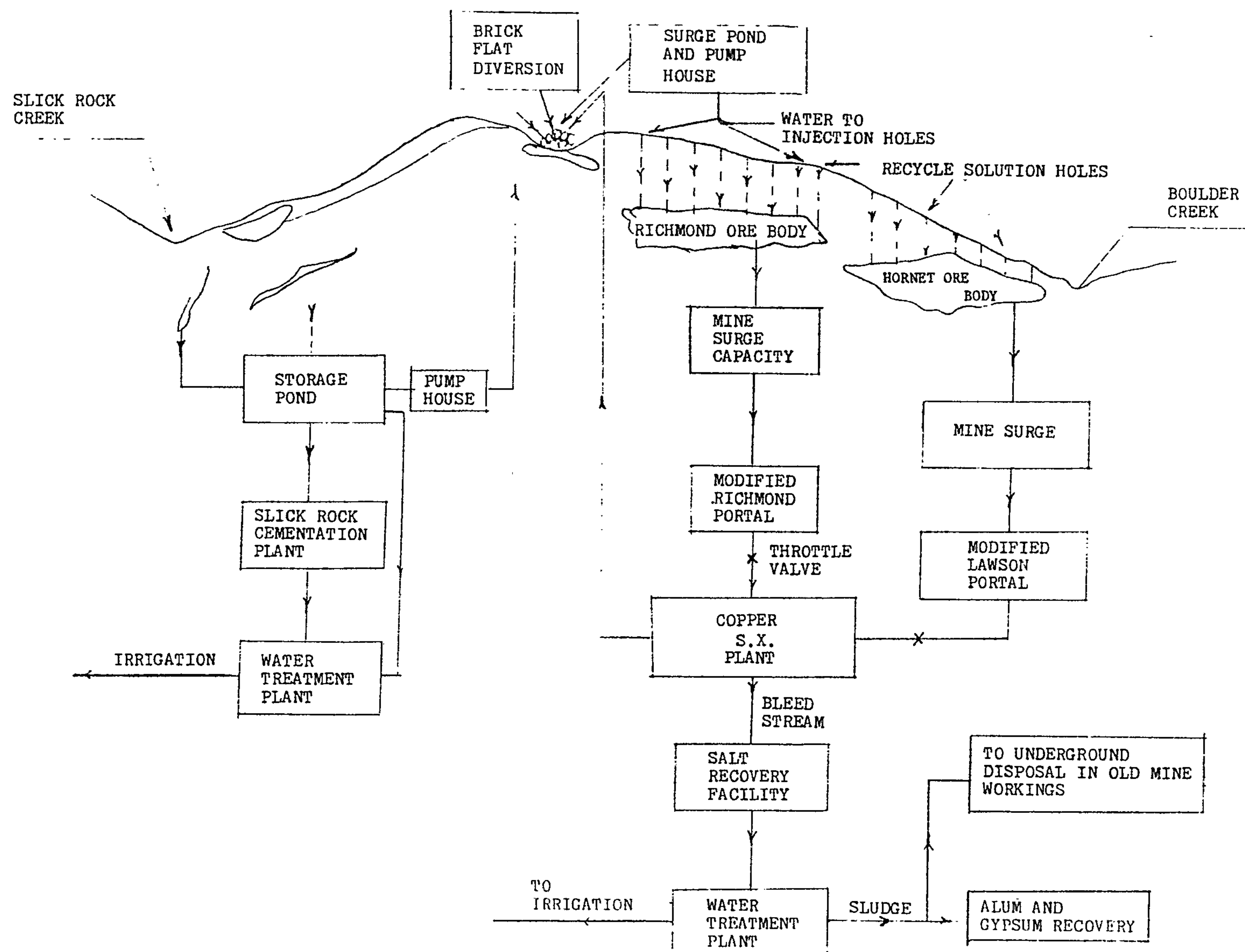
	(A) Metal Concentration	(B) Pounds Per Day	(C) Sacramento River Increment* (5000 cfs)
Cd	0.26	2.18	0.08 mg/l
Cu	1.71	14.0	0.52 mg/l
Zn	1.48	12.4	0.46 mg/l
Fe	2.0	16.8	0.62 mg/l

*These figures (in micrograms/liter) indicate the change in concentration in the Sacramento River at a flow rate of 5000 cfs if all of the treated water were accidentally discharged into the two creeks.

FIGURF B-1

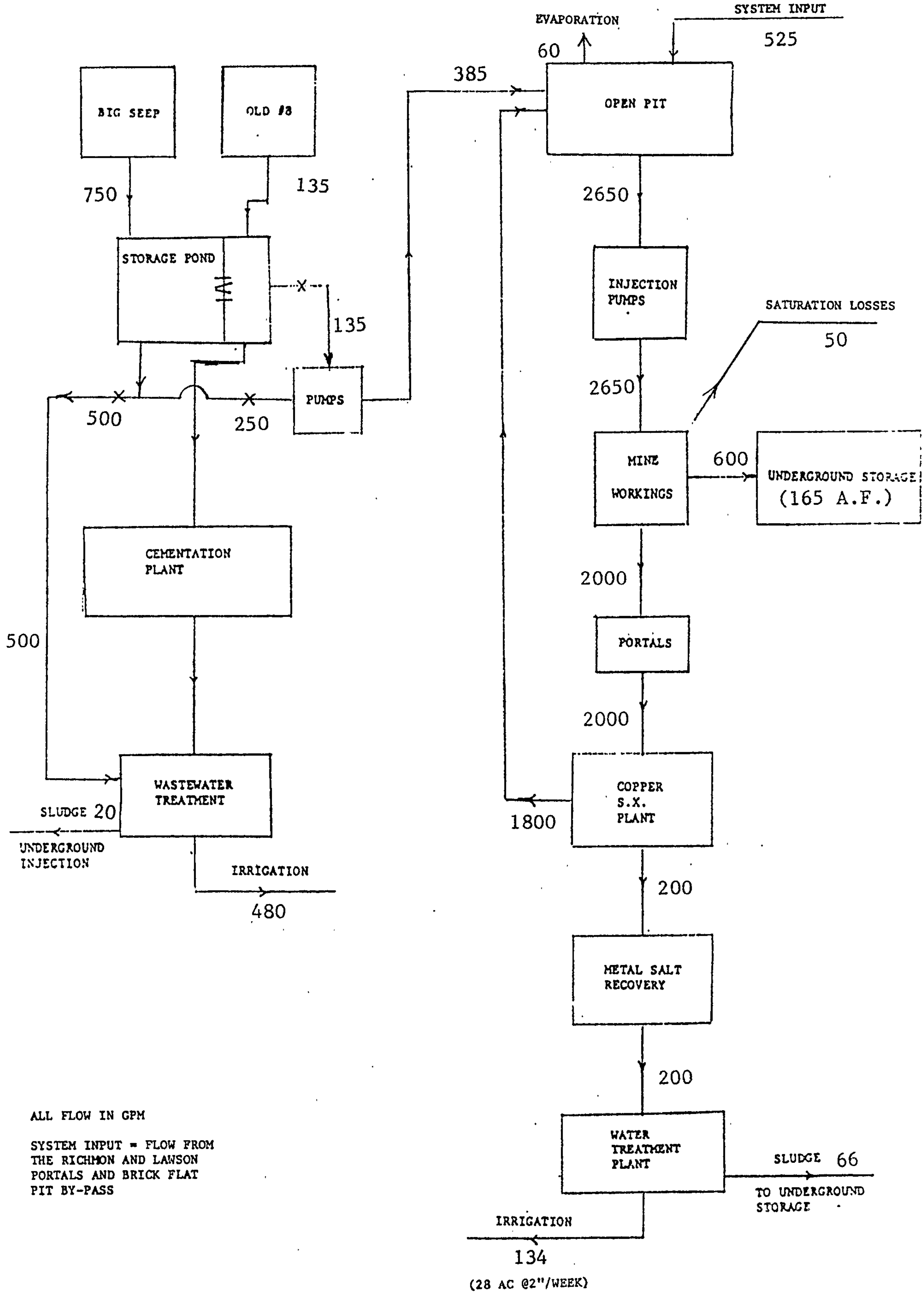
IRON MOUNTAIAN MINES INC.

MINE WATER MANAGEMENT SYSTEM



IRON MOUNTAIN MINES INC.

HIGH FLOW DEC.-JAN. WATER BALANCE



ALL FLOW IN GPM

SYSTEM INPUT = FLOW FROM THE RICHMON AND LAWSON PORTALS AND BRICK FLAT PIT BY-PASS

FIGURE B-3

IRON MOUNTAIN MINES INC.

NORMAL FLOW FEB.-JUNE

WATER BALANCE

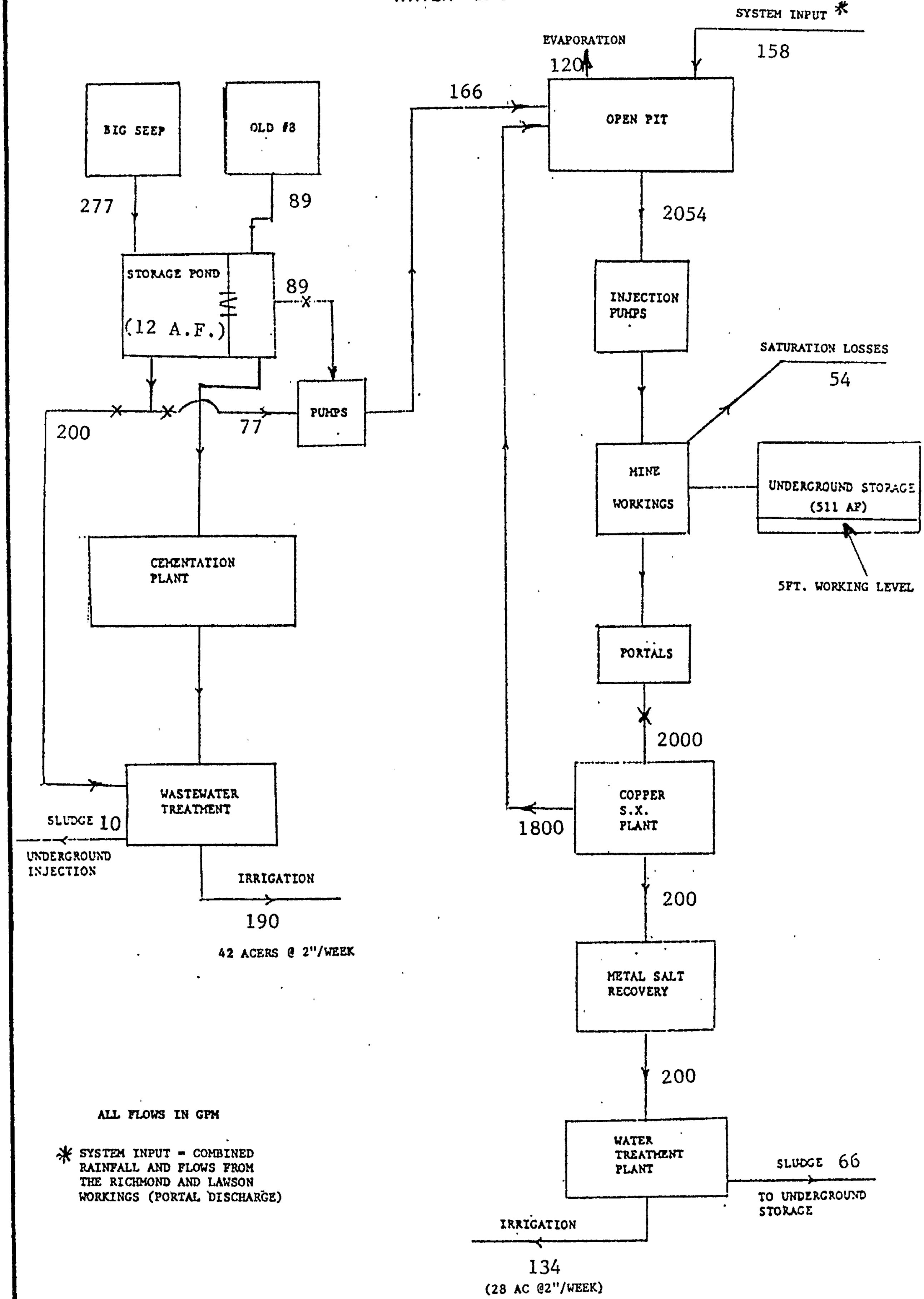
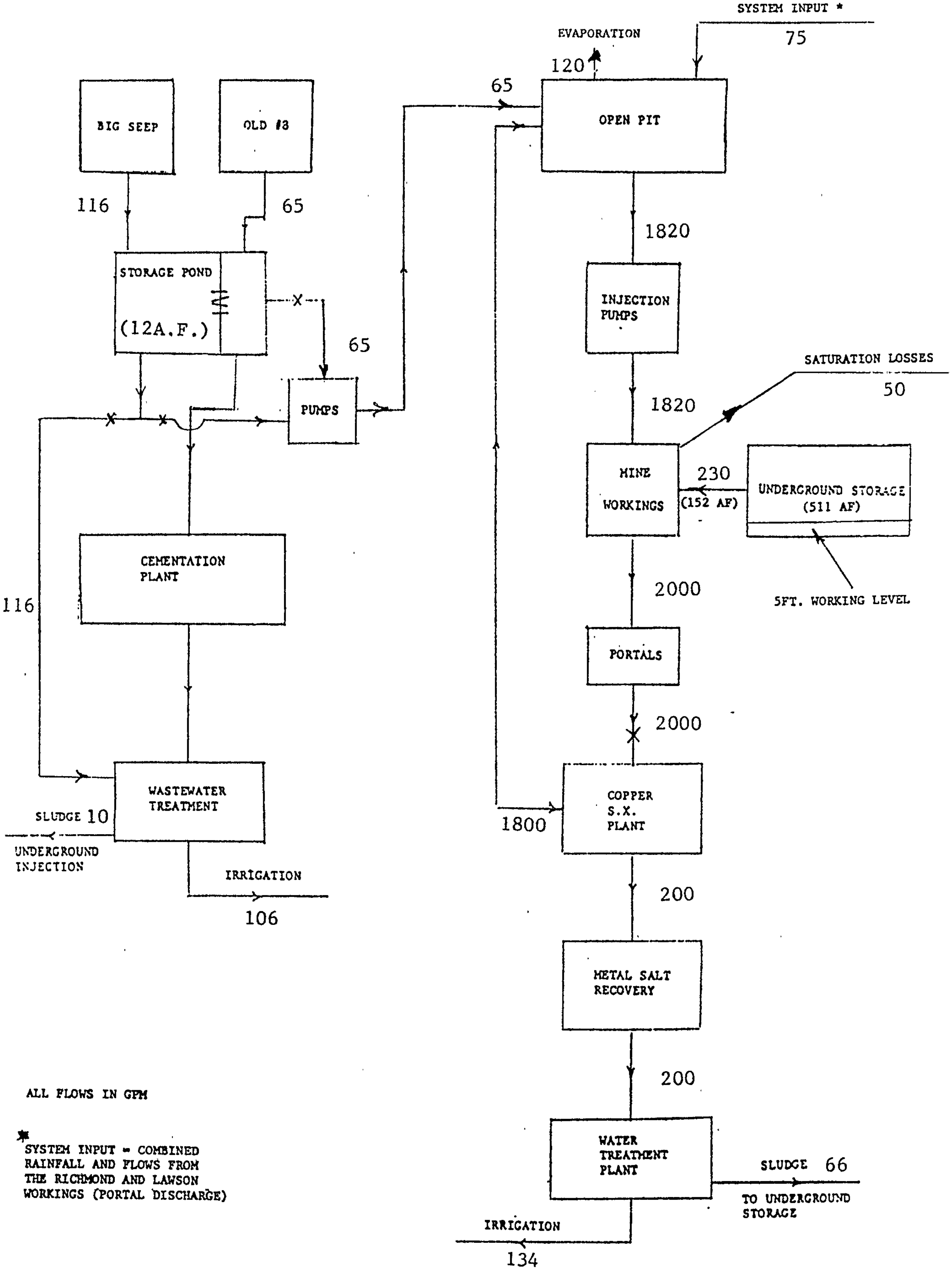


FIGURE B-4

IRON MOUNTAIN MINES INC.

LOW FLOW JULY -NOV.
WATER BALANCE



ALL FLOWS IN GPM

* SYSTEM INPUT = COMBINED RAINFALL AND FLOWS FROM THE RICHMOND AND LAWSON WORKINGS (PORTAL DISCHARGE)

APPENDIX C

Post Operational Conditions

The plant is expected to operate for a minimum of 15 years with the possibility of extending operations to 50 years. During this period, the costs of operating the treatment plants will be a minor portion of the plant operating expenses.

At the end of the operating period, the following terminal conditions are expected:

1. The IMMI area will have two efficient water treatment plants in operation with a total capacity of 1000 gpm which should accommodate normal flows.

2. The operation will be shut down gradually so that no severe overload condition is placed on the plants during the shut-down transition period.

3. The *in situ* water recycling injection system with access to all sections of the Richmond and Hornet mines can be used to introduce neutralizing solutions to cause *in situ* precipitation and gradual sealing of the flow channels to reduce water access and drainage. Experiments will be can be conducted during the operations period to develop techniques for mine sealing.

4. Plenty of time will be available during the operating years to reduce all the minor pollution sources to a minimum so that the volume from miscellaneous sources will be greatly reduced when shut-down occurs.

5. Both the Richmond and Lawson portals will have high pressure seals which permit both workings to be filled to prevent access of air, thus reducing the rate of production of acid and soluble heavy metals.

6. New technology will undoubtedly be available to control the acid mine water problem.

APPENDIX D

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