Southwest Ground-water Consultants, Inc.

REPORT
CONSERVATION AND CAP USE POTENTIAL OF TUCSON AMA MINES

FOR
ARIZONA DEPARTMENT OF WATER RESOURCES
TUCSON ACTIVE MANAGEMENT AREA

March, 27 1997

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Southwest Ground-water Consultants, Inc.

March 27, 1997

Ms. Ann Phillips
Water Resources Specialist
Arizona Department of Water Resources
400 West Congress St. Ste 518
Tucson, AZ 85701

Re: Contract No. 96-1281

Dear Ann:

Southwest Ground-water Consultants, Inc. and Cimetta Engineering and Construction Co., Inc. are pleased to submit this report on conservation and CAP water use potential of Tucson AMA mines. This completes our work under Contract No. 96-1281, as amended.

As required by the contract scope of work, this report describes current water use practices at the ASARCO Mission Complex and Cyprus Sierrita/Twin Buttes copper mines, identifies areas of additional ground-water conservation and assesses the potential for CAP water use by the mines. In assessing the potential for CAP water use, the costs of obtaining, transporting and using CAP water were estimated. These estimates include costs associated with obtaining legal right to CAP water, transporting it from the CAP terminus, maintaining a backup ground-water supply for periods when the CAP aqueduct is not operational and continuing to pump ground water in the vicinity of tailings ponds.

In addition to the foregoing costs, there may be costs associated with using CAP water in the mill flotation circuit that are not incurred using existing ground water. These potential costs include increased reagent use and decreased mineral recoveries. To assess these potential costs it will be necessary for the mines to test the use of CAP water in their facilities. Because specific mine tests are not available, costs associated with increased reagent use and decreased mineral recoveries are not included in the cost of CAP water presented in this report. These costs could be significant.

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It has been our pleasure to conduct this study. We appreciate the cooperation and support we have received from Tucson AMA staff and from mine personnel. If you have any questions regarding this report or any aspect of the study do not hesitate to contact us.

Sincerely yours,
Southwest Ground-water Consultants, Inc.

William M. Greenslade, P.E., R.G.
Project Manager

Registered Professional Engineer (Geological)
CERTIFICATE NO. 10313
WILLIAM MURRAY GREENSLADE
Date Signed 3/27/97
ARIZONA, U.S.A.

TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS

APP	Aquifer Protection Permit
ADEQ	Arizona Department of Environmental Quality

ADWR	Arizona Department of Water Resources
AF	acre-feet
AF/YR	acre-feet per year
AMA	Active Management Area
AWBA	Arizona Water Banking Authority
BADCT	Best Available Demonstrated Control Technology
CAWCD	Central Arizona Water Conservation District
cfs	cubic feet per second
DO	dissolved oxygen
EPA	Environmental Protection Agency
GWMA	Ground Water Management Act
HDPE	high density polyethylene
MAF	million acre-feet
NPDES	National Pollutant Discharge Elimination System
PV	present value
OM&R	operation, maintenance and repair
SX/EW	solvent extraction/electrowinning process
TDS	total dissolved solids
TPD	tons per day
TOC	total organic carbon
TSS	total suspended solids
WQARF	Water Quality Assurance Revolving Fund

EXECUTIVE SUMMARY

There are four copper mines in the Tucson Active Management Area (AMA). This study focused on the ASARCO Mission Complex and the combined activities of the Cyprus Sierrita and Cyprus Twin Buttes mines. These three mines use 99 percent of the ground water withdrawn by mines in the Tucson AMA.

The goal of this study was to identify additional ground water conservation potential at the mines and evaluate the potential for CAP water use by the mines. The conservation potential analysis will be used by the Arizona Department of Water Resources (ADWR) to help formulate mine conservation requirements in the Third Management Period (2000-2010) pursuant to the 1980 Ground Water Management Act. The analysis of CAP water use potential is intended to provide additional data on the major issues involved in order to encourage further examination of the use of this renewable water source.

Scope of this study was limited to the use of existing available data and assessment of significant water uses at the mines (processes constituting more than 10 percent of water use).

REGULATIONS AFFECTING WATER USE BY THE MINES

Ground water withdrawal rights and permits of around 62,000 acre-feet (AF) have been issued by ADWR to the Tucson AMA mines, The mines rely entirely on ground water and in 1995 pumped approximately 41,500 AF. Because of their existing ground water rights and permits, any shift to CAP use by the mines would be voluntary on their part.

Conservation requirements specified by ADWR in the Second Management Plan require mines to achieve tailings transport densities of 45 percent at existing facilities and 50 percent at new facilities, reduce and/or intercept tailings impoundment seepage, minimize evaporation from tailings pond surfaces, and recover and recycle tailings pond water. Facilities must also prepare conservation plans and annually report water use and mine production data.

Aquifer Protection Permit (APP) requirements Of the Arizona Department of Environmental Quality (ADEQ) require the use of Best Available Demonstrated Control Technologies (BADCT) including such provisions as lining ponds and retaining discharges on site. These requirements generally enhance conservation efforts. The need to continue to pump some groundwater to intercept potential tailings seepage precludes a complete shift to CAP water use by the mines. Any shift in discharge water quality characteristics at the mines due to changes in water sources or increased use of reagents would need to be evaluated by ADEQ.

Air quality regulations limiting particulate emissions impact water use at the mines because dust from haul roads, conveyors and tailings piles is typically controlled with water sprays. To date, no cost effective alternative to water use has been identified. A suitable alternative would not be precluded by the air quality regulations if discharge standards could still be met.

CURRENT MINE WATER USE

ASARCO Mission Complex currently processes about 63,000 tons per day (TPD) of ore through two flotation mills. Groundwater usage was approximately 13,800 AF in 1995 to process 22,149,000 tons of ore. Milling processes and tailings disposal accounted for about 94 percent of the total water consumed at the Mission Complex in 1995. Approximately 30 percent of water reporting (being delivered) to tailings piles is recovered and pumped back to the mill each year. The remaining 70 percent is lost to evaporation, retention in the tailings piles and seepage. The mill makeup water requirement increases or decreases about 485 AF per year for each one percent change in the density of transported tailings. Tailings densities at ASARCO average between 46 and 52 percent.

Cyprus Sierrita Corporation operates the contiguous Sierrita and Twin Buttes open pit copper mines. Cyprus Sierrita operates a single large flotation mill which processes around 110,000 TPD from both mines. Cyprus Sierrita recovers copper and molybdenum in the flotation process and operates a copper leach system. Ground water withdrawals in 1995 were approximately 27,400 AF with an associated 52,036,000 tons of ore processed through the mill or leached. Milling and tailings disposal activities accounted for 77 percent of total water consumption in 1995. Approximately 31 percent of water reporting to the tailings is recovered and recycled in the mill circuit. A one percent change in tailings density increases or decreases water use by an average of 787 AF per year. Tailings densities at Cyprus Sierrita average around 52 percent.

OPPORTUNITIES FOR ADDITIONAL CONSERVATION

Tailings transport is one of the major water uses at the mines. Increasing tailings slurry density, converting existing tailings transport piping to high density polyethylene (HDPE) material, and pumping tailings to the tailing dams instead of gravity feeding them, result in ground water savings. The mines are implementing some of these measures at this time and have plans to continue to upgrade existing systems and install new facilities incorporating these measures.

Management of free-water ponding on tailings is a major factor in water use efficiency at the mines. While the amount of water retained in tailings is largely beyond the control of mine operators, seepage from underneath tailings ponds can be reduced by depositing fine-grained tailings (slimes) on top of native soil before delivering tailings loads to these areas. The area of free water ponding on tailings piles is controlled using decant towers and barge pumps. Multiple decant towers can further reduce the area of the free-water surface. Minimizing the free-water surface must be accomplished consistent with air quality requirements for the mines.

Other mine water uses represent some conservation potential. Water may be conserved on leach piles by continuing to evaluate delivery methods other than the current sprinkler delivery system. The use of conveyors to transport materials out of the pit can save water on road dust control, and is being practiced at one mine and planned for another. Rainfall, surface water drainage, and dewatering water are additional sources of water at mines that are being put to use to some extent and should be examined further.

CENTRAL ARIZONA PROJECT (CAP) WATER USE BY THE MINES

Potential sources of CAP water for the mines include obtaining a CAP allocation, leasing an allocation from an existing allottee, purchasing excess CAP in years when it is available, or obtaining CAP through groundwater savings projects. In these projects, entities who provide CAP water, usually at a subsidized cost, to a farm or industry accrue long-term ground-water storage credits. The most expensive option is leasing CAP from an existing user, the least expensive option is to participate in a groundwater savings project

CAP water quality varies due to seasonal changes and inflow of surface water sources into the CAP canal. The mean total dissolved solids (TDS) in CAP water was 612 mg/l between 1987 and 1995, while the mean TDS in mine water was 317 mg/l at ASARCO Mission and 1,039 mg/l at Cyprus Sierrita. Total organic carbon and total suspended solids were not analyzed in mine water but are typically low in ground water; the mean values of these constituents in CAP water were 3.6 mg/l and 83 mg/l, respectively.

Impacts on copper and molybdenum recovery due to CAP use were examined in a 1983 laboratory test of flotation conducted at the University of Arizona. Testing results compared CAP water to groundwater and indicated a 0.6 percent decline in copper recovery and a 1.7 percent decline in molybdenum recovery when using 100 percent CAP water. The specific effects of CAP water on metal recovery at Tucson AMA mines will need to be determined in tests done at the respective mines. If CAP water were used at the mines, it would be mixed with ground water pumped in the vicinity of tailings impoundments and with water reclaimed from tailings ponds, prior to being used in the flotation process. To give an idea of the order of magnitude of potential lost income resulting from decreased mineral recoveries, a one percent decline in copper recovery at ASARCO Mission equates to about three million dollars in lost revenues per year. A one percent decline in copper and molybdenum recovery at Cyprus Sierrita equates to a annual loss of about two million dollars and one million dollars, respectively.

The reliability of CAP water in the Tucson Aqueduct is less than in the rest of the system because this portion of the aqueduct does not have redundant pumping facilities at the nine pumping stations along its length. Due to planned and unplanned outages on the aqueduct, the mines will need to maintain their current ground water pumping systems on standby to insure a continuous water supply to the mines,

Scenarios for delivering CAP water were developed. These include: obtaining a CAP allocation, leasing CAP water from existing allottees and entering into ground water savings projects. A 30-year planning horizon (the estimated life of the mines) was assumed. The analysis included estimated costs for constructing and maintaining pipelines and pumping facilities to the respective mines, purchase or lease of CAP water, maintenance of ground water pumping facilities as a back up for outages on the CAP and the continued pumping of wells to intercept potential seepage. Costs not included in the analysis included water pretreatment, loss of mineral recovery, and added mill reagent costs necessary to the flotation process. Costs for the CAP water scenarios were compared to the cost of continuing to pump ground water over the 30-year planning horizon. These present value costs are summarized in the following table.

Scenario	ASARCO Mission		Cyprus Sierrita	
	Cost ($)	**Cost/AF**	**Cost ($)**	**Cost/AF**
CAP Allocation/Excess	56,500,734	145	185,298,271	206
Lease CAP Water				
City of Tucson	59,800,734	153	191,898,271	213
Tohono O'Odham	50,110,276	128	172,517,354	192
Ground Water Savings Project	**37,119,817**	**95**	**146,334,553**	**163**
Ground-water Use	**23,035,026**	**59**	**100,580,919**	**112**

The least costly CAP water alternative to continued ground water use is a ground water savings project with the City of Tucson. The present value cost differential is $36/AF for the ASARCO Mission Complex and $51/AF for Cyprus Sierrita. These cost differentials are equivalent to approximately $0.002 per pound of copper produced at the ASARCO Mission Complex and $0.008 per pound of copper produced at Cyprus Sierrita.

1.0 INTRODUCTION

1.1 SCOPE OF WORK

Southwest Ground-water Consultants, Inc. is pleased to submit this report on the potential for conservation and CAP water use by the mines in the Tucson Active Management Area (AMA). The report is submitted to the Arizona Department of Water Resources (ADWR) in compliance with Contract No. 96-2181 dated July 19, 1996, as amended. The purpose of the study was to gather current data on mine water use and conservation practices, assess opportunities for further conservation and evaluate the potential for the use of CAP water.

The scope of work included five tasks, as follows:

- Task 1- Identify Current Use and Conservation Practices at Mines
- Task 2- Evaluate Opportunities for Ground-water Conservation
- Task 3- CAP Water Quality and Reliability
- Task 4- Impact of CAP Water on Mine Operations
- Task 5- Reports

Southwest Ground-water Consultants, Inc. and Cimetta Engineering and Contractors Company performed the above tasks. ADWR staff developed data and prepared sections of the report related to regulations and to CAP water allocations and cost.

Principal authors of the report and their primary area of responsibility and organization are:

Area of Responsibility	Author	Organization
Project manager, water supply, water quality, CAP reliability and use	William M. Greenslade	Southwest Ground-water Consultants, Inc.
Mine processes and cost estimating	Sherman Quayle	Cimetta Engineering and Construction, Inc.
Regulations and CAP allocations	Ann Audrey Phillips	Arizona Department of Water Resources

There are four copper mines in the Tucson AMA. The study focused on the ASARCO Mission Complex and the combined activities of Cyprus Sierrita and Cyprus Twin Buttes mines. These mines use 99 percent of the total ground water withdrawn by the metal mining sector in the Tucson AMA and operate relatively high water use flotation mills. ASARCO Silver Bell mine uses the less water intensive solvent extraction/electrowinning (SX/EW) process. Silver Bell is located about 23 miles from the CAP Aqueduct, making the use of CAP water uneconomic.

The study relied on existing available data. The scope of the study was limited to assessment of significant water use sectors, defined as those mine processes that constitute more than 10 percent of the total water use.

1.2 BACKGROUND

ADWR was created by the 1980 Ground Water Management Act (GWMA) to manage the water resources of Arizona. The Department's primary management activities relate to reducing ground-water overdraft in the five AMAs of the state. The metal mines addressed in this study are located within the Tucson AMA. The Tucson AMA covers 3,866 square miles in southeastern Arizona and includes two hydrogeologic subbasins as shown in Figure 1-1. The ASARCO Mission Complex, Cyprus Sierrita mine and Cyprus Twin Buttes mine are located in the Upper Santa Cruz Valley subbasin. The ASARCO Silver Bell mine is located in the Avra Valley subbasin.

The Tucson AMA has a statutory goal of achieving safe-yield by 2025. In order to achieve safe-yield, the amount of ground water pumped from the aquifers in the Tucson AMA on an average annual basis must not exceed the amount that is naturally or artificially recharged. The Tucson AMA currently depends on mined (overdrafted) ground water for roughly half of its supplies. Total water use in the Tucson AMA is over 300,000 acre-feet per year (AF/YR) (one acre-foot is equal to 325,851 gallons of water). Water sources used in the AMA in 1995 included mined ground water, renewable ground water, CAP, and treated wastewater effluent used directly on turf and agricultural fields as shown in Figure 1-2. Renewable ground water includes natural and incidental recharge. Natural recharge is the result of rainfall and runoff. Incidental recharge occurs when water seeps back to the aquifer after use and includes treated effluent discharged in the Santa Cruz River bed. As shown in Figure 1-3, metal mines accounted for about 68 percent of the 1995 industrial water use in the Tucson AMA, and 13 percent of total water use. Ground-water withdrawals by metal mines in 1995 were approximately 41,500 AF.

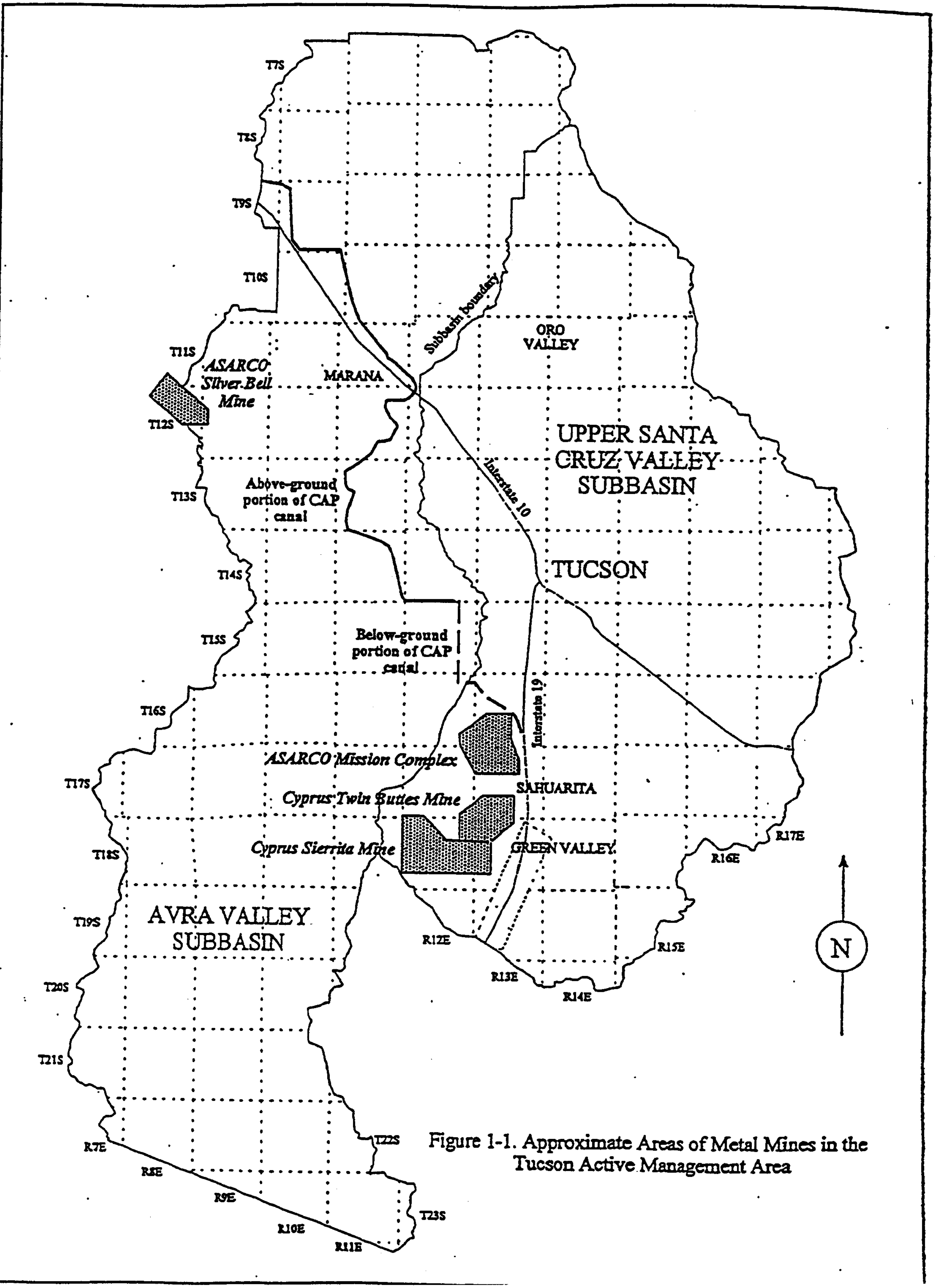
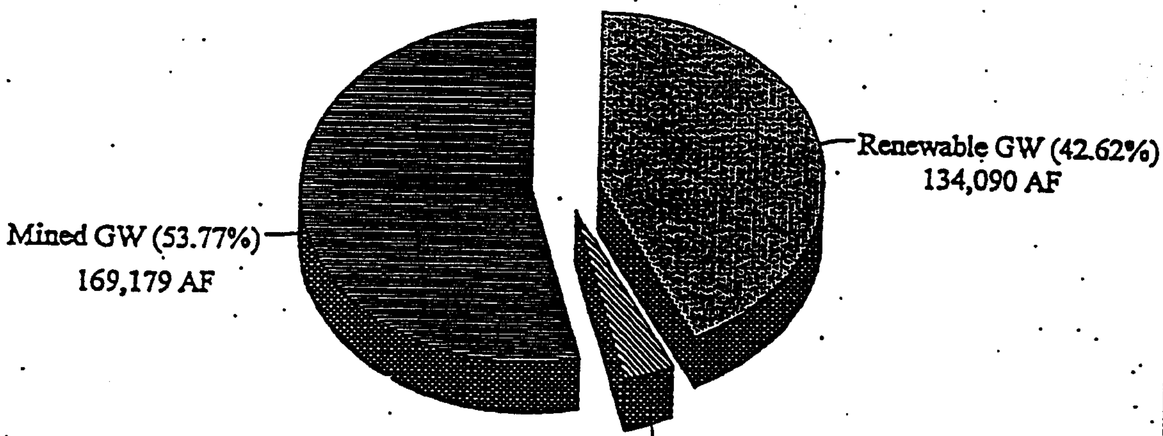


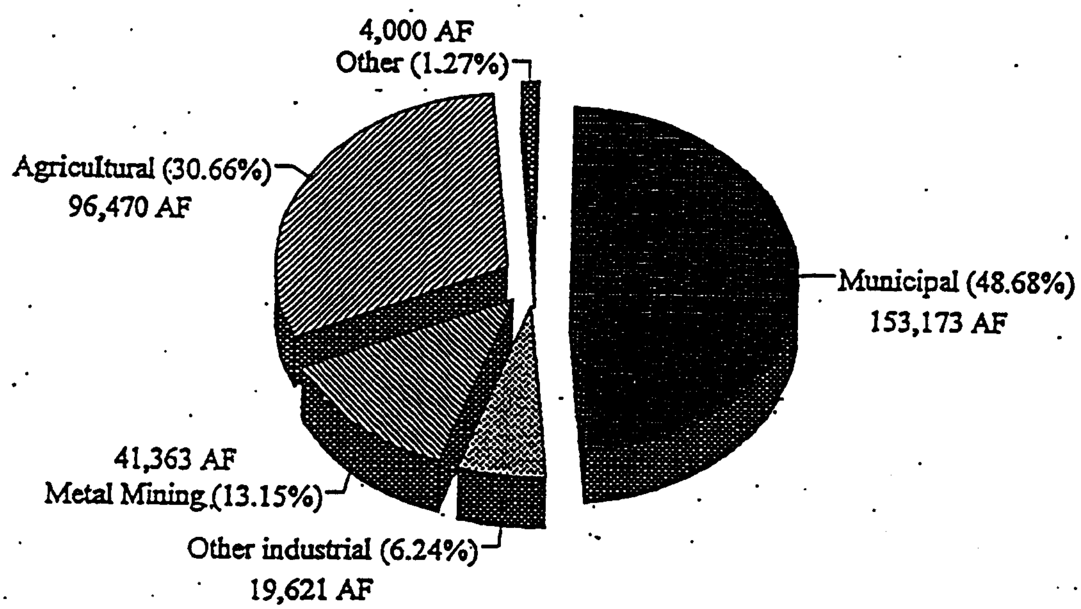
Figure 1-1. Approximate Areas of Metal Mines in the Tucson Active Management Area

Figure 1-2. 1995 Water Supply by Source - Tucson Active Management Area



NOTE: 10,138 AF of CAP water was delivered to agriculture in 1995 through groundwater savings programs. This CAP water is legally accounted for as mined groundwater.

Figure 1-3. 1995 Water Demand by Sector - Tucson Active Management Area



The GWMA requires ADWR to prepare a series of five management plans for each of the State's AMAs, covering the 45 year period between 1980 and 2025. The plans are intended to move the AMAs incrementally toward meeting their statutory management goals through conservation programs and increased use of renewable water supplies. The Second Management Plan currently in effect will continue through the year 2000. The Third Management Plan is being formulated at this time and will take effect on January 1, 2001 and continue through 2010. Information gained from this study will be used to formulate Third Management Plan conservation requirements for metal mines.

2.0 REGULATIONS AFFECTING WATER USE BY THE MINES

Federal, state and local regulations affect water use by metal mines. These regulations and their implications for mine water use are discussed below, beginning with state regulations.

2.1 STATE REGULATIONS

State agencies which have regulations relevant to water use at Tucson AMA metal mines include ADWR, the Central Arizona Water Conservation District (CAWCD), the Arizona Water Banking Authority (AWBA), the Arizona Department of Environmental Quality(ADEQ) and the State Mine Inspector's Office.

2.1.1 Arizona Department of Water Resources

ADWR oversees the management of ground water in Arizona. Aspects of ADWR's management responsibilities relevant to the metal mines' water use patterns include administering ground-water rights and permits, establishing conservation requirements for industry and administering permits for recharge projects.

2.1.1.1 Ground-water Rights and Permits

In order to withdraw more than 35 gallons per minute of ground water from a well inside an AMA, a ground-water right or permit is necessary. The GWMA established grandfathered rights to allow continued ground water use by those who have historically used ground water in the AMAs. Metal mines addressed in this study currently withdraw water pursuant to Type 1 and Type 2 grandfathered rights and ground-water withdrawal permits. These rights and permits are listed in Table 2-1. The allotment for a right or permit is an annual maximum. Excess allotment not used in one year does not carry over to subsequent years. Allotments are not decreased over time due to non-use. Annual withdrawal fees are assessed for each acre-foot (AF) of ground water withdrawn pursuant to groundwater rights and permits. Current withdrawal fees in the Tucson AMA are $3 per acre-foot per year (AF/YR). The ADWR collects an additional $2.12 per AF/YR up to a maximum of $10,000 per company and transfers it to ADEQ for use by the state's Water Quality Assurance Revolving Fund (WQARF). Ground-water withdrawal rights and permits are described below.

Table 2-1, Ground-water Rights and Withdrawal Permits in Use by the Mines

Mine	Right or Permit Number	Type of Right or Permit	Expiration Date of Permits	Annual Allotment (acre-feet per year)
ASARCO Mission	58-100306.0	Type 1 non-irrigation	NA	5,772.0
	58-115187.2	Type 2 mineral extraction	NA	250.0
	58-100315.4	Type 2 mineral extraction	NA	10,405.3
	58-160032.0	Type 2 mineral extraction	NA	1,158.0
				Total 17,585.3
ASARCO Silver Bell	58-100308	Type 2 mineral extraction	NA	2,755.0
	58-100305	Type 1 non-irrigation	NA	3,948.0
				Total 6,703.0
Cyprus Sierrita	58-113558.3	Type 2 mineral extraction	NA	22,805.6
	59-526051.0	Dewatering permit	1/03/00*	10.0
	59-540939.0	Dewatering permit	3/25/00	550.0
	59-550275.0	Dewatering permit	9/07/00	500.0
	58-100352.0	Type 2 mineral extraction	NA	17.3
				Total 23,882.9
Cyprus Twin Buttes	59-526050	Dewatering permit	11/21/99	900.0
	58-105307.6	Type 2 mineral extraction	NA	11,503.8
	59-087309.0	Dewatering permit	7/21/01	1,613.0
				Total 14,016.8

NA = Not applicable
* January 3, 2000

Type 1 rights Type 1 non-irrigation grandfathered rights apply to ground water which has been converted from irrigation use to a water use other than irrigation. Once it is converted to a Type 1 right, ground water can no longer be used for irrigation. Ground water used pursuant to a Type 1 right must be withdrawn from under the original irrigated land, though it can be piped for use away from this land. The maximum amount of ground water that can be withdrawn each year using a Type 1 right is 3 AF per acre of historically irrigated land.

Type 2 rights Type 2 grandfathered rights serve industries, golf courses, stock watering and other non-irrigation uses. Type 2 rights were established based on the maximum amount of ground water pumped in any one year between 1975 and 1980 by entities applying for these rights. Mineral extraction and processing, electric power generation, and general non-irrigation Type 2 rights were established. Type 2 rights established for one category of use cannot be transferred to another use. For example, mineral extraction and processing Type 2 rights cannot be used to generate electric power, but can be sold between metal mines and sand and gravel facilities. In general, Type 2 rights are more flexible than Type 1 rights because they can be sold separately from land and, with ADWR approval, can be used to withdraw ground water from a new location within the same AMA.

Ground-water withdrawal permits Ground-water withdrawal permits can be issued by ADWR for the withdrawal of ground water for non-irrigation uses in an AMA. There are eight types of withdrawal permits, each subject to different requirements. The most common type used by mining operations are dewatering permits (Table 2-1). Mineral extraction permits are also available for use by the mines. Applications for permits are reviewed by ADWR and granted for a limited period of time specified in the final permit. Permits cannot be leased or sold to other users and are tied to a specific use location.

Implications for mine water use A comparison of mine pumpage since 1988 with current ground-water allotments is given in Table 2-2. These data indicate that the mines could increase ground-water withdrawal in the future up to the limit of their allotments. If additional increases in ground-water withdrawal were needed by the mines, they could purchase or lease additional existing Type 1 and Type 2 rights from other users in the AMA. Additional permit-based withdrawals could be obtained following ADWR review. The ability of mines to continue to legally pump ground water makes any shift to renewable supplies, such as CAP water, voluntary on the part of the mines.

Table 2-2, Reported Ground-water Withdrawals from Mines, 1988-1995

Year	ASARCO Mission Allotment 17,585 AF/YR		ASARCO Silver Bell Allotment 6,703 AF/YR	Cyprus Sierrita Allotment 23,883 AF/YR	Cyprus Twin Buttes Allotment 14,017 AF/YR
1995	10,771(1)	2,982(2)	217	22,059	5,324
1994	10,038(1)	4,684(2)	182	22,674	5,946
1993	9,440(1)	4,250(2)	80	18,885	6,071
1992	9,023(1)	3,705(2)	234	16,961	6,920
1991	7,925(1)	1,466(2)	438	23,900	6,017
1990	7,086(1)	1,428(2)	406	17,887	5,636
1989	6,876(1)	2007(2)	532	18,684	3,499
1988	6,034(1)	821(2)	262	16,566	359

(1) Pumpage from ASARCO property pursuant to ground-water right and permit allotments
(2) Pumpage from San Xavier District by arrangement with the District, not subject to ground-water rights and permits

2.1.1.2 Second Management Plan Conservation Requirements

Mines using more than 500 AF of water per year are subject to the Second Management Plan conservation requirements for metal mining operations. Under the GWMA, AMAs must prepare management plans which include a conservation program for industrial users which requires the use of the latest commercially available conservation technology consistent with reasonable economic return. Conservation requirements for existing and new metal mines are briefly summarized below. The complete regulations are provided in Appendix A.

Requirements for existing facilities (operating or substantially commenced by 12/26/84):

- Transport tailings at average density of 45 percent
- Reduce leakage from tailings impoundments by compacting tailings up slope from the free water surface in ponds, or by installing interceptor wells
- Manage tailings impoundments to minimize water surface, maximize water depth, and recover decant water
- Recover and recycle pond water
- Cap abandoned tailings impoundments to minimize water used for dust control

Conservation requirements for new metal mining facilities:

- Manage tailings impoundments to minimize water surface, maximize water depth, and recover decant water
- Recover and recycle pond water
- Cap abandoned tailings impoundments to minimize water used for dust control
- Install new wells to maximize seepage interception
- Minimize seepage from new tailings impoundments using decant towers and interceptor wells
- Transport tailings at average density of 50 percent
- Submit conservation plan for new facility

Long-range conservation plan (new and existing facilities):

- Submit long-range conservation plan, include evaluation of the use of latest commercially available conservation technology consistent with reasonable economic return
- Analyze feasibility of using effluent, poor quality ground water, and CAP water; reducing tailings evaporation; minimizing water use for dust control on roads; increasing tailings density to 55 percent

Monitoring and reporting requirements (new and existing facilities):

- Submit annual report of ground-water withdrawal and water use data; mining, milling, and leaching tonnage; and density of transported tailings
- Determine the mathematical relationship between pond water depth and free water surface area in each pond, each year. Record biweekly pond depth, report yearly average pond water depth.

Facilities may apply for alternative conservation programs or to obtain temporary stays from conservation requirements. Both require submittal of documentation, review by ADWR and approval by ADWR's Director.

Implications for mine water use The Second Management Plan requires mines to actively recycle water. In addition to conservation requirements, metal mines have an incentive to recycle water in order to reduce water pumping costs. The long-range conservation plans submitted to ADWR by the mines addressed several additional techniques to conserve water. These included storm water capture and recycling, increasing tailings density above the required level, use of multiple decant towers to increase the rate of decant, reuse of pit dewatering water, paving of haul roads and switching to conveyor systems to replace truck haulage. Water recovered from tailings ponds and interceptor wells has reached up to 30 percent of total water use at the larger mines based on annual reporting by the mines. Water use patterns at the mines and the potential for additional water conservation are discussed in Sections 3.0 and 4.0. Additional conservation potential will be addressed in conservation requirements being developed for the Third Management Plan.

2.1.1.3 Recharge Rules and Regulations

Artificial recharge is the deliberate addition of water to aquifers and is administered statewide by ADWR under the 1994 Underground Water Storage, Savings and Replenishment Program. The potential use of CAP water at the mines would not directly recharge water to the aquifer but could theoretically accomplish "indirect" recharge. Indirect recharge, known as "ground-water savings programs" or "in-lieu" recharge, allows existing ground water to remain underground by replacing ground-water pumpage with renewable water supplies. CAP water and effluent are the renewable supplies available in the Tucson AMA.

CAP water is used here to describe how ground-water savings programs work. In their simplest form, these projects have two main partners, Partner 1 (usually a governmental body with access to CAP water) supplies CAP water to Partner 2 (usually a farm or industry) who puts CAP water to use. Partner 1 may subsidize the cost of delivering CAP water in order to make it possible for Partner 2 to use the water. With this cost subsidy, Partner 2 may pay no more to use CAP water than it would have paid to pump ground water. Partner 1 accrues recharge credits and at some point in the future can recover the credits by pumping "recovered" CAP water (physically ground water). At the time the credits are recovered, ADWR considers the pumped ground water to be CAP water for regulatory and accounting purposes. At the time the CAP water is physically used at the farm or industry, it is considered to be "ground water" for ADWR regulatory and accounting purposes. Ground-water withdrawal fees are paid by the CAP water user.

ADWR reviews and issues permits for ground-water savings facility arrangements. To proceed with this type of arrangement, Partner 2 must not be able to reasonably use CAP water except through a ground-water savings arrangement and cannot have another reasonably available water source at their disposal other than ground water. Partner 2 must agree to use CAP water on a gallon-for-gallon substitution for ground water they would otherwise have pumped. ADWR records Partner 1's accrual of credits in the amount of CAP water supplied to Partner 2, less 5%, which is the "cut to the aquifer". Partner 1 may sell, lease, exchange, or give away these credits, or may pump "recovered" CAP water from permitted recovery wells in the amount of the accumulated storage credits. Credits may only be accrued through the year 2025. The benefits to Partner 1 include putting their CAP allocation to work, accruing recharge credits at less cost than it would take for direct recharge, and saving ground water for future use at which time it will be considered CAP water for ADWR's regulatory purposes. The benefits to Partner 2 are obtaining CAP water at a subsidized cost and putting CAP water to use, thus saving ground water for future use.

Implications for mine water use Entering into a ground-water savings arrangement may be one option for making CAP use economically viable for the metal mines. The City of Tucson has the largest CAP allocation in the Tucson AMA, and is receptive to entering into a dialog with the mines on the potential for ground-water savings arrangements (Tucson Water, 1997). Additional partners may include CAWCD and the ABWA, as discussed below. Details of a ground-water saving option for the mines are discussed further in Section 5.3.4.

2.1.2 Central Arizona Water Conservation District (CAWCD)

The CAWCD (also known as CAP) was created in 1971 with the mission of contracting with the U.S. Secretary of Interior to repay construction costs for the CAP aqueduct and establish contracts for CAP water. The agency was later given the task of operating and maintaining the CAP aqueduct. CAP water can be obtained from CAWCD under allocated subcontracts, reallocated subcontracts, relinquishment or exchange of subcontracts or through acquisition of "excess CAP water" -- water which was earmarked for delivery through the CAP aqueduct but which has not been allocated under subcontracts. CAWCD also provides CAP water to the AWBA. CAWCD establishes the prices charged for delivery of CAP water.

Implications for mine water use CAWCD's role in supplying and setting prices for CAP water affects all users of this water supply. Availability and pricing of CAP are described in detail in Section 5.1.2. In addition to supplying water, CAWCD can act as a financial partner in building and operating systems delivering and recharging CAP including direct recharge and ground-water savings projects. CAWCD has expressed a willingness to discuss the potential for ground-water savings facility recharge arrangements with the Tucson AMA metal mines (CAWCD, 1997).

2.1.3 The Arizona Water Banking Authority (AWBA)

Currently, Arizona does not use its entire 2.8 million AF entitlement of Colorado River water. The AWBA was created in 1996 to replenish ground-water aquifers in Arizona using the uncommitted portion of this entitlement. Each year, the AWBA will purchase a portion of Arizona's unused entitlement, bring it into central Arizona via the CAP aqueduct, and store it for future use. This storage is necessary because Arizona may receive less than its full entitlement during years of shortage on the river. The AWBA can recharge water by participating in both direct recharge projects and ground-water savings projects.

Implications for mine water use The AWBA could consider participation as a partner in ground-water savings projects with the metal mines (AWBA, 1996). The Bank has the option of supplying CAP water for recharge at a subsidized rate. The AWBA typically participates in groundwater savings arrangements with irrigation users on a year-to-year basis. A long-term partnership would be needed to make participation in a groundwater savings arrangement viable for the mines. This would require negotiations between partners to design a suitable long-term groundwater savings facility. The potential for the AWBA to supply CAP water to the mines is discussed in Section 5.3.4.

2.1.4 Arizona Department of Environmental Quality (ADEQ)

ADEQ oversees environmental protection in the state. Aspects of ADEQ's management responsibilities relevant to mine water use include the Aquifer Protection Permit program, state involvement with federal permits issued under the Clean Water Act and state involvement with federal air quality standards. Aquifer Protection Permits are discussed below. ADEQ's involvement with Clean Water Act permits and federal air quality standards are discussed in the following section on federal regulations.

Aquifer Protection Permits (APPs) are issued by ADEQ under the state's Environmental Quality Act. The APP program regulates facilities that may discharge pollutants to the land surface, soil, or ground water in order to prevent ground-water contamination. Metal mines must apply for Individual APPs, a process that requires submittal of a hydrologic report on the mine site and detailed review by ADEQ before issuance of a site-specific permit. Final APPs for the mines have not yet been issued by ADEQ.

Implications for mine water use The APP program requires specific mechanisms known as Best Available Demonstrated Control Technologies (BADCT) to control site discharges. Because these address pond lining, storm water management, and reduction of site discharges, among other engineering controls, they can have a positive effect on mine water management practices. Conversely, pumpage of interceptor wells to control tailings seepage may also be required by ADEQ, a requirement that would presumably continue even if other ground-water withdrawals at a mine could be replaced with CAP water. The impact of continued interceptor well pumpage on possible conversion to CAP water is addressed further in Section 5.1.5. Potential changes in discharge water quality at the mines due to changes in water sources or increased use of reagents or other chemicals would need to be reviewed by ADEQ.

2.1.5 Arizona State Mine Inspector's Office

The Mined Land Reclamation Rules are administered by the Arizona State Mine Inspector's office as required in the 1994 Arizona Mined Land Reclamation Act. The rules took effect in October 1996 and address the reclamation of surface disturbances of greater than five acres at metal mines and exploration operations after cessation of mining activities. Existing facilities must submit a mine reclamation plan by April 1, 1997. The type and amount of revegetation that may be undertaken after facilities cease mining will vary from site to site.

Implications for mine water use Reclamation plans for Tucson AMA mines will be reviewed as they become available to determine their impact on water use by the mines. It is not anticipated that mine reclamation plans will appreciably impact water use patterns at operating mines, though establishing vegetation on reclaimed areas may require some initial commitment of water.

2.2 FEDERAL REQUIREMENTS MANAGED AT THE FEDERAL, STATE AND LOCAL LEVEL

Regulatory programs originating in the Clean Water Act which might potentially impact water use at metal mines include Section 402 permits under the National Pollution discharge Elimination System (NPDES). ADEQ manages NPDES permitting efforts with federal oversight and review. ADEQ and Pima County manage air quality permitting depending on the facility; both have federal oversight and review.

2.2.1 National Pollutant Discharge Elimination System (NPDES)

The federal government regulates discharges to the waters of the U.S. through the NPDES program. NPDES permits are issued by the U.S. Environmental Protection Agency (EPA) under the federal Clean Water Act. Permit applications are processed by ADEQ with the oversight of EPA, which issues the actual permit. The NPDES program applies to waters of the state and nation including perennial and intermittent waters and surface and subsurface water whether public or private. NPDES permits are required for point source discharges and storm water runoff.

NPDES Point Source Permits (Section 402) The NPDES permit for Point Sources of Pollution provides authorization for point source pollutant discharges under the condition that monitoring, reporting and control requirements are fulfilled. Cyprus Twin Buttes mine was issued an

NPDES permit in 1991, but this permit has subsequently been put on inactive status (ADEQ, 1997). The permit addressed dewatering at the east pit using ground-water wells and discharge of the water to the Santa Cruz River. The permit required that the water be tested for metals, common ions and other components prior to discharge (PAG, 1996). The dewatering was conducted under dewatering permits issued by ADWR. Two dewatering permits are still in effect at Twin Buttes (Table 2-1).

Implications for mine water use Water is no longer being discharged to the Santa Cruz River from Twin Buttes mine pursuant to an NPDES permit. Water withdrawn pursuant to these permits totaled 10 AF in 1995 and was retained on site. Water obtained from current and future dewatering activities is and will be reused on site. Water reuse is discussed in more detail in Sections 3.1 and 3.2.

NPDES Storm Water Permits (Section 402p) The Clean Water Act was revised in 1987 to expand NPDES permit coverage to storm water discharges associated with industrial activity and to cities above a certain size. NPDES Storm Water Permits are designed to ensure that discharges meet water quality standards by establishing permit requirements for certain industrial and construction activities that discharge storm water. Storm Water Management Plans submitted by facilities address storm water discharge points and water quality measurements.

Implications for mine water use Facilities are not required to retain storm water on site, but some mines do retain storm water and recycle it back through the leaching and milling process. This water may be used to offset ground-water withdrawals, as discussed in Section 4.6.

2.2.2 Air Quality Permits

Air quality permitting is designed to protect public health from the adverse effects of pollutants discharged into the air by industry, and to keep emissions from exceeding National Ambient Air Quality Standards. ASARCO Mission Complex permitting is overseen by Pima County Department of Environmental Quality. ADEQ manages air quality permitting for certain larger facilities, including Cyprus Sierrita and Twin Buttes Mines. Regulatory standards for air quality address limits for air pollution which cannot be exceeded. The mechanisms used to meet the standards are chosen by the facilities themselves and described in permit applications.

Implications for mine water use Mines use a variety of techniques to reduce emissions to the air including water sprays in contained environments which enable recycling, and water sprays in open areas. Water trucks periodically wet roads, and the mines keep portions of tailings piles wetted to reduce dust emissions. In their permit applications the mines specify the approaches they will use to meet air quality standards. They may modify these strategies as long as they continue to meet emission standards. Use of road binders or other chemicals on mine surfaces may need ADEQ review to determine their environmental impacts. Water use and dust control are discussed in Sections 4.5.3 and 4.5.5.

3.0 CURRENT MINE WATER USE

The copper mines in the Tucson AMA rely exclusively on ground water for their water supply. Ground-water withdrawals in 1995 were 41,363 AF, as shown on Figure 1-3. This section of the report describes the volume of water use, conservation practices, and ground-water quality at the ASARCO Mission Complex and Cyprus Sierrita mines.

3.1 ASARCO Mission Complex

The ASARCO Mission Complex is an open pit copper mine located approximately 16 miles south of Tucson, Arizona. The mine currently processes about 63,000 tons per day (TPD) through two flotation mills. The South Mill throughput is 20,000 TPD, while the Mission Mill processes 43,000 TPD. Average ore copper grade is 0.65 percent. ASARCO Mission Complex does not operate copper leaching facilities.

Water supply for the mine is ground water. ASARCO Mission Complex operates 11 ground-water production wells located east of the mine near the intersection of Pima Mine Road and Interstate 19 (T16S, R13E, Sections 26, 35 and 36). Ground-water usage is approximately proportional to the amount of ore processed. Ground-water withdrawals and ore milled by the mine, as reported to ADWR, are given in Table 3-1.

Table 3-1, Ground-water Withdrawals and Ore Milled
ASARCO Mission Complex, 1987-1995

Year	Acre-feet	Ore Milled (Tons)
1987	6,054	9,926,200
1988	6,855	10,180,700
1989	8,883	12,998,900
1990	8,514	13,852,600
1991	9,391	14,245,800
1992	12,728	19,859,100
1993	13,690	21,528,900
1994	14,722	23,296,297
1995	13,753	22,149,100

3.1.1 Water Use

Water use at the ASARCO Mission Complex in 1995 is shown on Figure 3-1, a schematic diagram of the mine's water balance. Consumptive water use by mine sector is given in Table 3-2. Consumptive use decreases the water circulating through the mine and must be replaced with makeup water.

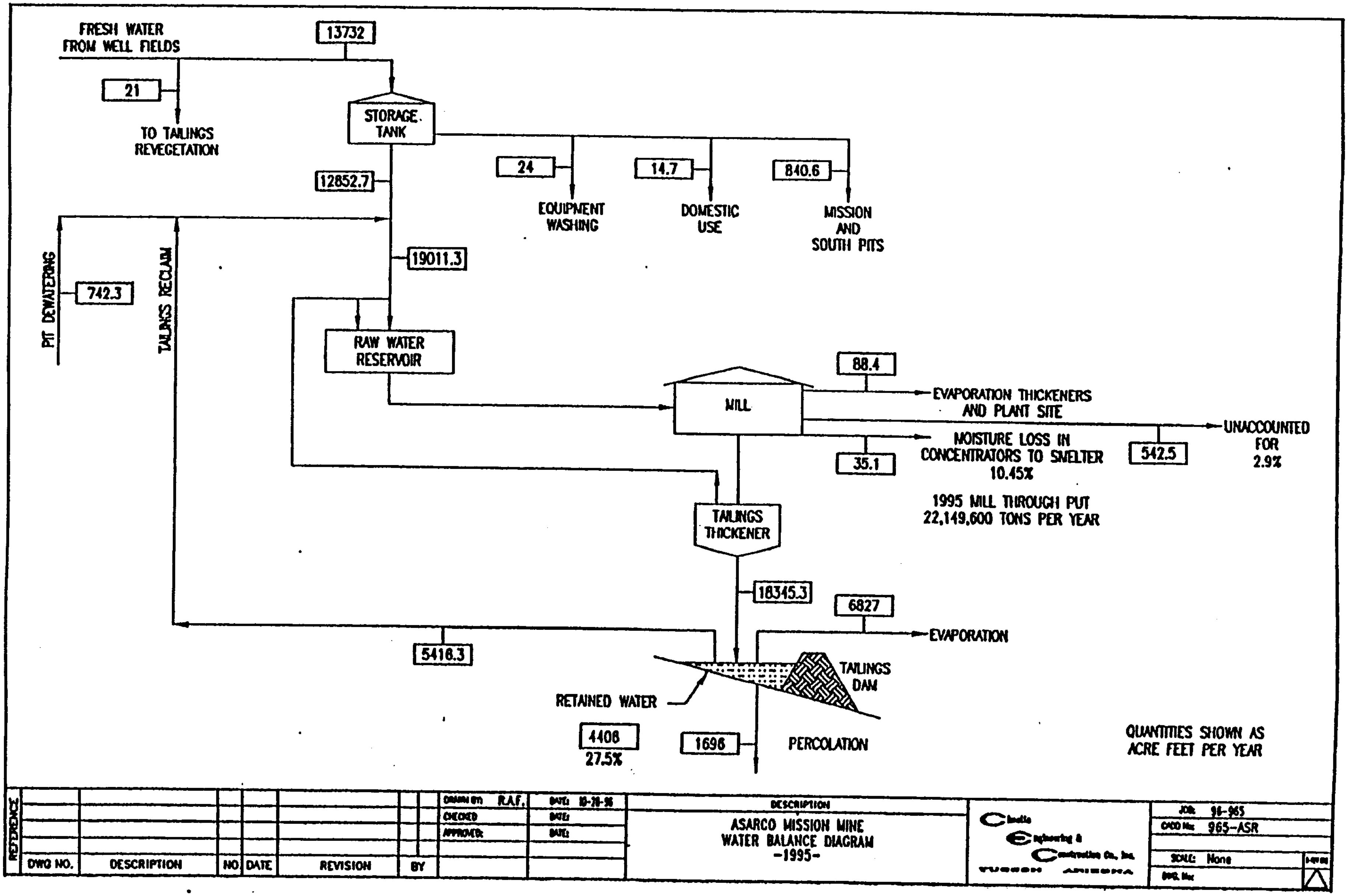


FIGURE 3-1
ASARCO MISSION WATER BALANCE, 1995

Table 3-2, ASARCO Mission Complex Water Consumption, 1995

Sector	Acre-feet per year	Percent of Total
Revegetation	21	0.2
Equipment Washing	24	0.2
Domestic	14.7	0.1
Mining (Dust Control)	840.7	6.1
Milling-related uses:		
Evaporation		
Thickeners and reservoirs	88.4	0.6
Tailings Ponds	6.827	49.6
Retained in Tailings	4,406	32.0
Retained in Concentrates	35.1	0.3
Seepage from Tailings	1,696	12.4
Unaccounted Loses	542.5	3.9
(Less Pit Dewatering)	(742.3)	(5.4)
TOTAL WATER CONSUMPTION	13,753	100

The vast majority of water use at the Mission Complex is in milling of the ore and disposal of the tailings. These activities accounted for approximately 94 percent of the total water consumption in 1995.

3.1.2 Water Conservation Practices

Mine processes and associated water conservation measures are discussed below. Current water conservation practices at the Mission Complex are focused primarily on recycling and reclaiming process water.

Mining starts in the open pit where ore and waste rock are hauled out of the pit in trucks. Various haul road dust control agents, including pine oils, lignin sulfonate, coherex, magnesium chloride and others have been tested. However, none have proved to be sufficiently cost effective to be adopted by ASARCO. Most of the agents are reported to make the roads very slick when wet, require too frequent applications or are not cost effective.

Once at the surface, ore is crushed and delivered by conveyor to the mill where it is ground to a fine powder. Water is added in the mill grinding circuit to produce a slurry which feeds into the flotation circuit. This slurry is about 30 percent to 35 percent solids by weight. Following removal of copper bearing material using the flotation process, the flotation tailings (the remaining waste product) are sent to the tailings thickeners where the solids settle out and the slurry is thickened prior to transport to the tailing dam.

Two process streams are produced at the thickeners. Thickener overflow is clear water which flows over the top of the thickener tanks and is recycled back to the mill. Thickener underflow is a high density product containing the solids and sufficient water to transport these solids in pipelines to the tailings dam. The range of thickener underflow typically runs from 45 percent solids to 55 percent solids by weight. This varies depending on the particle size, the specific gravity of the ore, temperature, tailings pipe size and flow velocity. It varies from mine to mine, and even from area to area within the same mine due to changes in the mineralization and host rock.

The largest single factor affecting the rate of ground water withdrawal at the mine is the operation of the tailings transport and disposal systems. Varying the density of thickener underflow at ASARCO Mission has a significant effect on the amount of water being delivered to the tailings dam, as shown in Table 3-3. The average difference in water use for a one percent variation in the percent solids delivered to the tailings dam is 696 AF/YR.

Table 3-3, ASARCO Mission Complex Tailings Solids Versus Water Volume

Tailing Solids (%)	Acre-feet Per Year
45	20,698
46	19,892
47	19,085
48	18,347
49	17,634
50	16,935
51	16,263
52	15,645
53	15,016
54	14,435

Approximately 30 percent of water sent to the tailings is recovered and pumped back to the mill. The remaining 70 percent of water reporting to the tailings is lost to evaporation, retention in the tailings dam, and seepage. The mill makeup water requirement therefore increases or decreases an average of approximately 485 AF (70 percent of 696 AF) per year for each one percent change in tailings thickener underflow density.

In 1995, the ASARCO Mission Mill thickener discharge system was modified. A dart valve was installed which enabled the mill to increase the percent solids in the tailing slurry from approximately 46 percent to 49 percent. This reduced mill water makeup requirements by about

1,000 AF. The South Mill tailings vary from 48 percent to 54 percent solids and average around 50 percent. The Mission Mill tailings thickener underflow density is controlled by an electronic pinch valve. Mission Mill tailings vary between 46 percent and 52 percent solids depending on the ore types, and averages about 48 percent.

ASARCO currently operates five tailings facilities. The South Mill uses the No. 7 and No. 8 tailings facilities, both of which have center decant towers. These towers decant tailings reclaim water to a collection pond. The reclaim water is then pumped to the mill water reservoir. The Mission Mill uses tailing facilities No. 1, No. 2 and No. 3. These facilities' dams also have decant towers and reclaim sumps from which the reclaim water is pumped to the Mission Mill water reservoir. The current Mission tailings facilities have about five years of life remaining. A new No. 4 tailings facility has been designed and is now in the permitting process. This facility is designed for the projected 30-year life of the mine.

3.1.3 Water Quality

Water quality data for ASARCO Mission production wells were limited to data available in the APP application for Tailings Facility No. 4. A total of four sample results were available, as follows:

Well	Sample Date
M-8	8/21/90
M-10	8/22/90
M-11	8/22/90
M-13	3/83

In 1995, these wells produced a total of 7,081 AF, about 52 percent of the total annual ground-water withdrawals. Minimum, maximum and mean values for general inorganic constituents in these wells are given in Table 3-4.

Table 3-4, Selected Production Well Water Quality
ASARCO Mission Complex

PRODUCTION WELLS M-8, M-10, M-11, M-13	Maximum	Minimum	Mean
pH (units)	8.1	7.9	8.03
Alkalinity (mg/l $CaCO_3$)	133	126	131
Bicarbonate (mg/l HCO_3)	162	102	145
Calcium	49	24	35
Magnesium	12	1.3	5.18
Hardness (mg/l $CaCO_3$)	172	69	108
Sodium	62	53	57
Potassium	3.5	2.5	3.0
Chloride	28.3	5.7	14.8
Fluoride	1.4	0.9	1.2
Nitrate	9.3	1.8	4.6
Sulfate	110	64	88
Total Dissolved Solids	400	265	317
Conductivity (µmhos/cm)	570	410	462

Notes: All results are in milligrams per liter (mg/l) unless specified otherwise., µmhos/cm - Micromhos per centimeter

The quality of water produced by ASARCO Mission's production wells varies from well to well as indicated by the range in total dissolved solids (265 mg/l to 400 mg/l). Water delivered to the mine is a blend of water from individual wells, reducing the variability in water quality used in mine processes. No data are available on the quality of the blended water or its variability over time. Some variability is anticipated, however, when wells are turned on and off for maintenance or repair.

3.2 CYPRUS SIERRITA

Cyprus Sierrita Corporation operates the Sierrita and Twin Buttes open pit copper mines. These mines are on contiguous properties located approximately 10 miles south of ASARCO's Mission Complex and 26 miles south of Tucson. Ore is mined and processed at Sierrita. Ore is not currently being mined at Twin Buttes, however, stockpiled ore from Twin Buttes is being processed at Sierrita.

Cyprus Sierrita operates a single large flotation mill with a throughput of 110,000 TPD. Average ore copper content is 0.29 percent. Sierrita ore also contains significant amounts of molybdenum, approximately 0.029 percent. Increases in mill capacity are being pursued, with an ultimate target capacity of 200,000 TPD.

Cyprus Sierrita also operates a heap and dump leach facility. Acid soluble copper is leached from mine waste dumps and from new material placed on piles specifically designed for leaching. A weak acid solution is sprayed over the top of the rock and collected again after it seeps through the rock and dissolves the soluble copper. The recovered copper bearing solutions are processed in a solvent extraction plant where the copper is stripped out of solution and electrolytically plated as cathode copper. The tail solution from the solvent extraction plant is reacidified with sulfuric acid and returned to the leach distribution system, where it is applied to the heaps and dumps to leach more copper. Make up water is added to replace water lost through evaporation and moisture retention in the dumps.

3.2.1 Water Use

The Cyprus Sierrita operation relies on ground water for its water supply. Ground water is pumped from the Canoa, Esperanza and Twin Buttes well fields and from the Interceptor well field. Annual groundwater withdrawals and tonnage processed at Cyprus Sierrita and Twin Buttes mines are shown in Table 3-5. Data in this table are taken from annual reports submitted to ADWR. These withdrawals include only 51 percent of the water pumped from Cyprus Sierrita's interceptor wells. These wells are designed to intercept tailings seepage water, however, they pump both tailings seepage water and ground water. By agreement with ADWR, 51 percent of the water pumped is assumed to be groundwater and is reported to ADWR.

Table 3-5, Ground-water Withdrawals
Cyprus Sierrita/Twin Buttes, 1987-1995

Year	Acre-feet	Tons Processed (Milled and Leached)
1988	16,925	33,359,164
1989	22,183	36,870,422
1990	23,523	37,489,468
1991	29,917	43,180,000
1992	23,881	50,550,000
1993	24,956	46,304,000
1994	28,620	47,961,000
1995	27,383	52,036,948

A flowchart of water usage at Cyprus Sierrita is shown in Figure 3-2. Water consumption by mine sector is given in Table 3-6. Total water pumpage in 1995 was 30,627 AF. Ground water withdrawals reported to ADWR were 27,383 AF, the difference being the amount of assumed seepage from the tailing ponds captured by the interceptor wells.

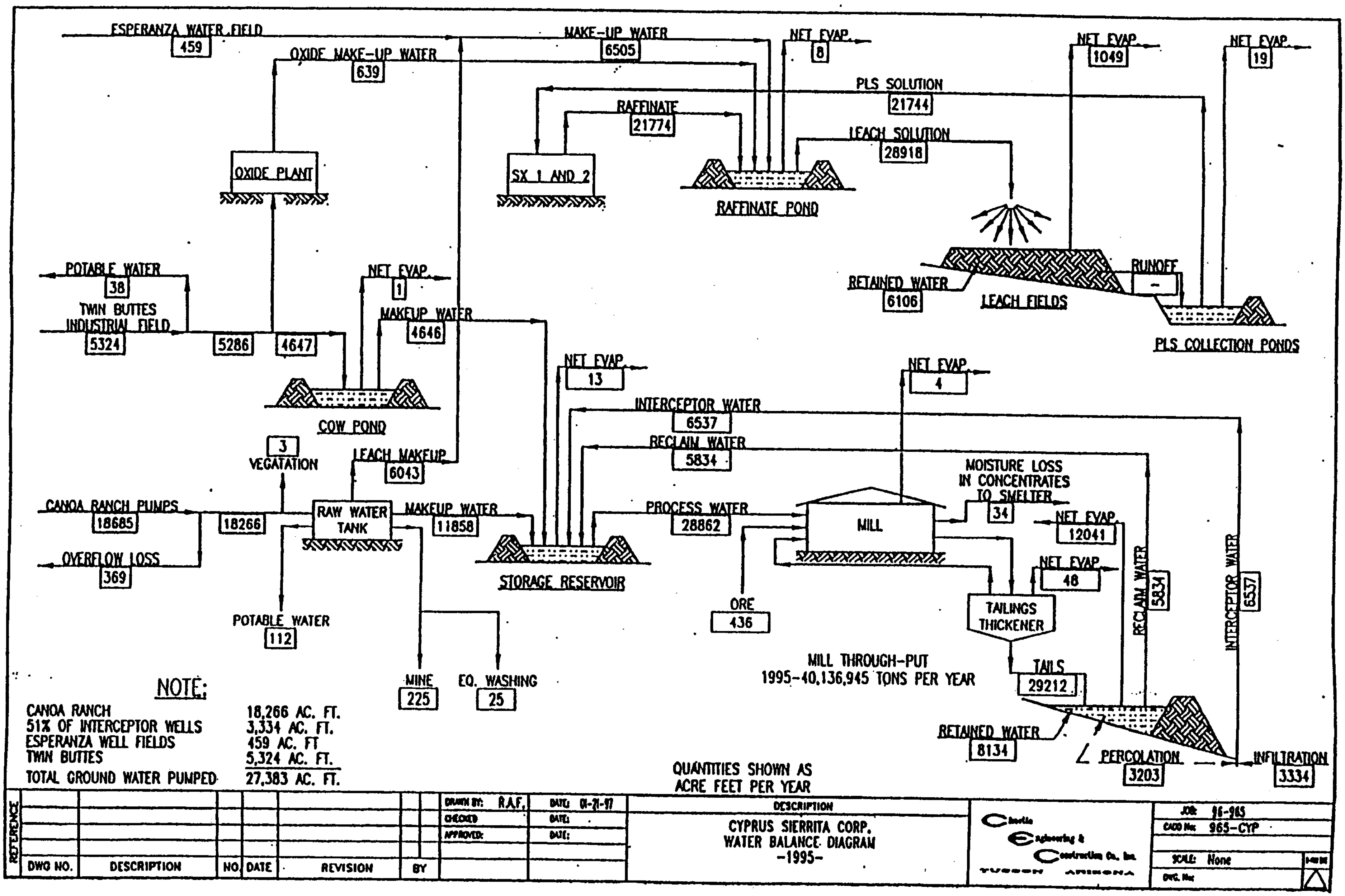


Figure 3-2
Cyprus Sierrita Water Balance, 1995

Table 3-6, Cyprus Sierrita/Twin Buttes Water Consumption, 1995

Sector	Acre-feet per year	Percent of Total
Revegetation	3	>0.1
Equipment Washing	25	>0.1
Domestic	150	0.5
Mining (Dust Control)	225	0.7
Evaporation (Plant Site)	14	>0.1
Milling-related Uses:		
Evaporation (Thickeners & Mill)	52	0.2
Evaporation (Tailings Pond)	12,041	39.3
Retained in Tailings	8,134	26.6
Seepage from Tailings	3,203	10.5
Retained in Concentrates	34	0.1
(Less Water in Ore)	(436)	(1.4)
Leaching-related Uses:		
Evaporation (Leach Field, PLS Pond and Raffinate Pond)	1,076	3.5
Retained in Leach Piles	6,106	19.9
TOTAL WATER CONSUMPTION	30,627	100

3.2.2 Water Conservation Practices

Cyprus Sierrita mines from two open pits. Ore is crushed in the pits and transported via conveyors to the secondary crushers at the mill. Waste rock is hauled from the mine by truck. Dust control is by water sprays in the conveyors and on haul roads. As at ASARCO Mission, various dust suppressants have been evaluated, however none have proven successful.

At the Cyprus Sierrita mill, new, more efficient ceramic disc filters have been installed to reduce the moisture content of concentrate shipped to the smelter. Moisture content has been reduced by about four percent, or approximately 11 AF/YR.

Cyprus Sierrita currently operates four tailings thickeners. Underflow from these thickeners ranges from 48 to 55 percent solids with an average around 52 percent. Table 3-7 gives the volume of water needed to slurry tailings of different solids contents. The average difference for a one percent variation in solids to the tailings dam is 1,141 AF/YR.

Table 3-7, Cyprus Sierrita Tailings Solids Versus Water Volume

Tailings Solids (%)	Acre-feet Per Year
48	32,034
49	30,744
50	29,569
51	28,410
52	27,295
53	26,223
54	25,189

Approximately 31 percent of the water reporting to the tailings is recovered and pumped back to the mill water circuit. Sixty-nine (69) percent is lost to evaporation, retention in the dam and seepage. Mill make-up water is increased or decreased an average of 787 AF per year for each 1 percent change in tailings thickener underflow density.

Cyprus Sierrita operates one large 2,800 acre tailings dam. Tailings are discharged over the dam berm. The flow is directed toward the reclaim pond by a series of sectional dikes constructed with track dozers. Portable pumps are used to pump reclaim water back to the mill water reservoir.

Cyprus Sierrita has 22 interceptor wells at the base of their tailings dam to intercept seepage water from the tailings impoundment, 11 of which were put into operation in 1996. The 1996 interceptor wells have a design capacity of 2,500 gpm (4,160 AF/YR). The effect of the 1996 interceptor wells is to increase reclaim tailings water by approximately 2,000 AF/YR, with a corresponding reduction in ground-water pumping.

Slope dewatering wells have been drilled in the pit walls to improve slope stability. Water from the wells is reclaimed in the bottom of the pits and used as makeup.

3.2.3 Water Quality

In 1995 total makeup water to the mill circuit was 23,041 AF. This makeup water was supplied by Canoa well field (51%), Interceptor well field (28%), and Twin Buttes well field (20%). The Esperanza well field supplies makeup water to the leach circuit only. In the past few years several lined storm water impoundments have been constructed at Sierrita. The impounded water is recycled to the leach dumps as makeup water, reducing ground-water pumping from the Esperanza well field.

Tables 3-8 through 3-10 give the minimum, maximum and mean values of inorganic constituents in ground water from the well fields supplying the mill. Table 3-11 gives the mean inorganic water quality, weighted by well field flows, of makeup supplied to the mill.

Table 3-8, Selected Canoa Production Well Water Quality, 1993-1995
Cyprus Sierrita

PRODUCTION WELLS: S-1, S-2, S-3, S-4, S-5	Maximum	Minimum	Mean
pH (units)	7.9	6.9	7.6
Alkalinity (mg/l $CaCO_3$)	188	136	153
Bicarbonate (mg/l $CaCO_3$)	306	146	169
Calcium	107.5	23.90	60
Magnesium	15	1.60	6.9
Hardness (mg/l $CaCO_3$)	331	98	179
Sodium	140.1	2.7	57.6
Potassium	5.7	2.1	3.5
Chloride	708	8.4	33.5
Fluoride	1	0.3	0.6
Nitrate	4.0	0.7	2.0
Sulfate	246	17	101
Total Dissolved Solids	754	212	376
Conductivity (µmhos/cm)	988	296	533

Notes: All results are in milligrams per liter (mg/l) unless specified otherwise.
µmhos/cm - Micromhos per centimeter

Table 3-9, Selected Interceptor Well Water Quality, 1996 Cyprus Sierrita

PRODUCTION WELLS: I-3, I-4, I-5, I-8, I-9, I-10	Maximum	Minimum	Mean
pH (units)	8.0	7.7	7.8
Alkalinity (mg/l $CaCO_3$)	219	137	173
Calcium	734	498	590
Magnesium	123	98	108
Hardness (mg/l $CaCO_3$)	2,339	1,653	1,920
Sodium	278	116	172
Potassium	12.62	7.8	10.7
Chloride	253	128	181
Nitrate	1.8	1.0	1.5
Sulfate	1,833	1,419	1,576
Total Dissolved Solids	3,256	586	2,402
Conductivity (µmhos/cm)	3,640	2,780	3,150
Turbidity (NTU)	0.6	0.4	0.5

Notes: All results are in milligrams per liter (mg/l) unless specified otherwise.
µmhos/cm - Micromhos per centimeter

Table 3-10, Selected Twin Buttes Production Well Water Quality, 1995 Cyprus Sierrita

PRODUCTION WELLS: TB 7, TB 9, TB 10, and TB 12	Maximum	Minimum	Mean
pH (units)	7.6	7.2	7.4
Alkalinity (mg/l $CaCO_3$)	118	93	108
Calcium	245	102	188
Magnesium	32.1	14.8	25.2
Hardness (mg/l $CaCO_3$)	747	317	577
Sodium	78.4	26.5	54.0
Chloride	75.4	24.6	52.1
Fluoride	0.41	0.3	0.34
Nitrate	2.96	1.17	2.17
Sulfate	651	100.9	447.7
Total Dissolved Solids	1,252	362	876
Conductivity (µmhos/cm)	1,609	549	1,227
Turbidity (NTU)	0.55	0.41	0.46

Notes: All results are in milligrams per liter (mg/l) unless specified otherwise.
µmhos/cm - Micromhos per centimeter

There is a significant difference in the quality of water produced by each well field. Canoa well field water is lowest in dissolved constituents (376 mg/l TDS). The Interceptor well field is highest (2,402 mg/l TDS), with the Twin Buttes well field supplying intermediate quality water (876 mg/l TDS).

Water from these well fields is blended in the mill storage water reservoir. The flow weighted mean water quality of makeup water delivered to the mill, based on 1995 well field production rates, is given in Table 3-11

Table 3-11, Flow Weighted Water Quality
Cyprus Sierrita

PARAMETER	Weighted Mean
pH (units)	7.6
Alkalinity (mg/l $CaCO_3$)	148
Calcium	234
Magnesium	38.9
Hardness (mg/l $CaCO_3$)	744
Sodium	88.4
Chloride	78.3
Nitrate	1.9
Sulfate	582
Total Dissolved Solids	1039
Conductivity (µmhos/cm)	1399

Notes: all results are in milligrams per liter (mg/l) unless specified otherwise
µmhos/cm - Micromhos per centimeter

4.0 OPPORTUNITIES FOR ADDITIONAL CONSERVATION

This section discusses opportunities for additional water conservation at Tucson AMA mines. The majority of water use is in the milling and leaching circuits, water conservation in other areas of the mines has relatively little impact on the total amount of ground-water use.

Current water use practices at the mines include reclaiming and reuse of water. It is generally less expensive to reclaim water than to pump ground water. The distance and lift required to pump ground water from the well fields to the mill is greater than from the tailings or leach facility. Reclaim water is also preconditioned (having already been through the mill circuit) compared to makeup water from wells, which reduces the amount of reagent that needs to be added in the mill.

4.1 OVERVIEW OF TAILINGS WATER MANAGEMENT

The control, or lack of control, of water is a major factor in the relative stability of the tailings embankment and in the control of evaporation. A tailings facility with a properly designed water-control system will make the most economical use of the available water resources.

Water flows into a tailings dam in the tailings slurry from the mill, as water from direct precipitation on the tailings structure, and/or as surface or underground runoff water from drainage basins upstream and adjacent to the tailings structure. Water leaves a tailings structure by evaporation, by seepage through the tailings embankment and the materials underlying the tailings facility and/or as free water through decant systems, diversion works or spillways.

From the standpoint of stability and economics, it is desirable to control the amount of water flowing into the tailings structure and to regulate the manner in which water leaves a tailings structure. The amount of water which enters the tailings structure with the tailings can be regulated within a somewhat narrow range (as discussed subsequently). The inflow of water due to direct precipitation over the tailings cannot be controlled. The inflow due to surface runoff can be controlled indirectly by site selection. A tailings embankment built on flat ground will have no inflow from surface runoff. A side-hill tailings structure will be subject to a moderate runoff inflow volume derived from the ground surface immediately adjacent to the embankment. A cross-valley tailings structure will receive the greatest volume of runoff inflow which will come from the entire drainage area upstream from the structure.

A significant degree of control can be exercised to regulate the manner in which the water leaves a tailings structure. With the proper selection of control methods, the engineer can either maximize or minimize the evaporation, seepage, or free water outflow volumes to achieve desired end results. But certain factors related to the specific milling procedure and site conditions are, for all practical purposes, inalterable. These include the physical and chemical characteristics of the ore, the local climate, the maximum volume of inflow water which can be expected to enter the tailings structure, and the geology of the tailings structure site.

Each milling operation produces a specific type of tailings with unique physical and chemical characteristics. The water content of the tailings slurry varies from operation to operation depending on the chemical and physical nature of the ore, the thickeners being used and the type, location and condition of the tailings discharge lines.

The graduation of the solid tailings material will also vary for each ore refining process. Mill tailings particles typically vary in size from medium sand size (1 millimeter (mm) in diameter) to clay size (less the 0.002 mm in diameter). The overall permeability of the tailings structure is directly related to the relative size of the tailings particles. A tailings structure composed of fine-grained material can be expected to lose much less water by seepage than a structure composed of coarse tailings. At the copper mines in the Tucson AMA, approximately 25 percent of the particles are less than 0.037 mm in diameter (400 mesh). As a result, these tailings piles retain significant amounts of the water (approximately 27 percent by weight) sent to the tailings facility.

The most common method of controlling the production free water (the water that enters the tailings structure with the tailings slurry) is the use of decant systems. Decant systems are of two general types:

- A decant tower and decant line system in which the water leaves by gravity flow through buried pipelines at the bottom of the tailings embankment, and

- A surface system in which the water leaves through siphons or pumps leading to surface pipelines over the top of the tailings structure.

Both of these systems are in use by mines in the Tucson AMA. ASARCO Mission uses decant towers on its existing tailings piles and plans to continue with this system at its new tailings facility No. 4. Cyprus Sierrita uses floating pump barges that pump reclaimed tailings water back to the mill water storage reservoir. Both mines reclaim around 30 percent of the water sent to the tailings facilities.

The control of free, or ponded, water on the tailings facility is important for embankment stability as well as water conservation. Keeping the pond water surface back from the tailings embankment generally improves embankment stability. It also reduces the water surface area and, therefore, evaporation.

Subsequent subsections of this report discuss the opportunities for conservation of water that is sent to the tailings pile, is retained in the tailings pore space, seeps through the bottom of the tailings structure, or is lost to evaporation.

4.2 TAILINGS TRANSPORTATION

The volume of water used in tailings transport depends on the percent solids in the tailings slurry from the thickener underflow. The higher the percentage of solids the less water reports to the tailings structure as shown in Tables 3-3 and 3-7. Less water going to the dam means lower evaporative and seepage losses and reduced reclaim pumping costs. The maximum feasible percentage of solids in the tailings slurry depends primarily on the type and condition of the slurry pipelines and on the elevation of the thickeners and tailings pile surface relative to one another.

Both the ASARCO Mission and Cyprus Sierrita mills originally used either concrete, concrete-lined steel or transite pipe to transport tailings. These pipes were subject to occasional pipe failure and the loss of tailings and water. Most of the pipe used in transporting reclaim water was steel. Almost all new and replacement piping is now high density polyethylene (HDPE) pipe which has a lower friction factor than concrete or transite pipe. This lower friction factor reduces head loss which results in greater flow in gravity lines and lower horsepower requirements in pump lines. In both instances higher slurry densities are achievable over other pipeline materials. HDPE pipe is also more abrasion resistant and more corrosion resistant reducing the loss of tailings and water through pipe failure.

At the present time both ASARCO Mission and Cyprus Sierrita transport tailings by gravity. ASARCO Mission is planning to construct a new tailings dam in a location that will allow the mine to transport tailings by gravity over the projected life of the mine. This facility will utilize HDPE piping.

Cyprus Sierrita expects to shift in the next few years from gravity feed to a pumping system to transport tailings to the existing dam. This will require the installation of a tailings pumping station.

Both ASARCO Mission and Cyprus Sierrita are operating their tailings slurry at a density of between 46 and 55 percent. Average annual density is approximately 48 and 52 percent, respectively. This exceeds the Second Management Plan (SMP) requirement of 45 percent for existing facilities. It should be possible to achieve an average annual tailings density of 50 to 54 percent with replacement of concrete pipelines at both ASARCO Mission and Cyprus Sierrita and with the pumping of tailings at Cyprus Sierrita.

4.3 WATER RETENTION IN TAILINGS AND LEACH FACILITIES

Water is retained in the pore space of rock material due to capillary action and surface tension. The finer grained the material, the more water retained. For copper tailings, which have a relatively high percentage of silt and clay sized particles, the water retained is approximately 27 percent of the dry weight of the tailings. At ASARCO Mission and Cyprus Sierrita this amounted to 4,406 AF and 8,134 AF, respectively, in 1995.

The amount of moisture retained in a leach pile is directly related to the ore type and material size. Dumps made with run-of-mine material typically contain four percent to five percent moisture. When applying leach solution to these dumps, the moisture content must be raised to approximately ten percent before any solution will flow to the sump. Leach dumps that are constructed of material that is crushed require more solution to be applied before flow through the dump is achieved. At Cyprus Sierrita, 6,106 AF of water was retained in leach piles in 1995. ASARCO Mission does not have a leaching operation.

The amount of water retained in tailings and leach piles is largely beyond the control of the mine operator because it is a function of the mineral extraction process which is, in turn, a function of the characteristic of ore being mined.

4.4 TAILINGS SEEPAGE

Combined seepage from the ASARCO Mission and Cyprus Sierrita tailings facilities in 1995 was estimated to be 4,899 AF, or 12 percent of total ground-water withdrawals by the mines. Unlike water evaporated or retained in the tailings, seepage is not 'lost', since it returns to the ground-water aquifer. However, due to concerns about water quality ADEQ requires that mines minimize seepage from their tailings facilities. This is accomplished by covering the native ground surface underlying the tailings facilities with low permeability, fine-grained tailings materials, called slimes. Permeability of the tailings material at the bottom of the piles is also reduced by compaction as tailings are added to the piles. BADCT for new tailings facilities requires a liner under the tailings with a permeability of 10^{-6} cm/sec.

4.5 EVAPORATION

Water is lost through evaporation at several points in the mine circuit, as shown on Figures 3-1 and 3-2. Areas of losses are discussed below.

4.5.1 Water Storage Reservoirs

ASARCO Mission's raw water is pumped from the well field to a covered storage tank near the mill. Makeup water flows from the tank to miscellaneous uses at the mine and to the mill raw water reservoir where it is mixed with tailings reclaim water. The mill raw water reservoir is an open concrete-lined structure with a surface area of approximately 2/3 of an acre. Evaporation from this reservoir is estimated to be 3.4 AF/YR.

Cyprus Sierrita's raw water is pumped from the well field to a mill water reservoir. This reservoir is a clay lined pond near the mill and receives both makeup water and tailings reclaim water. The surface area is approximately 2.8 acres with an estimated annual evaporation loss of 14.8 AF.

Total water lost from these reservoirs is approximately 18.2 AF/YR, or 0.04 percent of the total ground-water withdrawn. Some reduction in evaporation could be realized by covering these reservoirs, however, the amount of water savings does not appear to justify the cost.

4.5.2 Tailings Thickeners

Tailings thickeners in Arizona are generally not covered. Evaporation from the surface of the thickeners at the ASARCO Mission Complex and Cyprus Sierrita is approximately 100 AF/YR or 0.2 percent of the total ground-water withdrawn in 1995. The cost of covering these facilities, which would reduce but not eliminate evaporation, does not appear to be justified by the water savings.

4.5.3 Size of Free-Water Ponds on Tailings Piles

It is necessary to have a free-water pond covering a portion of the surface area of tailings piles to allow the slow settling slime fraction in tailings to settle out. Mines attempt to minimize this free-water surface and to recover the water for recycling to the mill. Good operating procedures must be used to direct the spigoting and deposition of tailings to the free water pond. Minimizing the free-water pond area is an extremely effective method of water conservation because tailings pond evaporation accounts for 40 to 50 percent of total water consumption at the mines.

All ASARCO Mission tailings facilities use a decant tower system to reclaim tailings pond water. These tailings piles are constructed on relatively flat ground which is conducive to the decant tower recovery system. To conserve water, ASARCO Mission combined tailings facilities No. 1 and No. 2 to form a single tailings surface. This reduced the surface acreage of the free water pond, with a corresponding reduction in evaporation. The new No. 4 tailing facility has been designed with three decant towers to maximize the rate of water recovery and minimize the size of the free water pond. The pump-back system will have 60 percent greater pumping capacity than is required. The ground below the tailings facility will be preslimed (covered with fine grained tailings deposits) to reduce seepage.

Cyprus Sierrita's tailings facility uses barge mounted pumps to reclaim water. This facility was constructed on more steeply sloping ground, resulting in the choice of a barge pump recovery system. While it is a priority to minimize free water surface, factors other than operational criteria can influence pond size. In the early 1990's, in an effort to reduce blowing dust from the tailings dam, Cyprus Sierrita increased the size of the pond to keep more of the surface under water and reduce the dry area subject to wind erosion.

Traditionally, the Cyprus Sierrita tailings pile was raised using the upstream construction technique, where tailings are slurried by gravity around the perimeter of the embankment. To facilitate lift-construction and pipeline-movement, the structure was divided into two sections and slurry was deposited on one-half of the dam until it was full. If construction and pipeline work was completed before the operating half was full, as was generally the case, the other half of the dam was left idle and dry. The cycle time between sections was approximately eight months. Various dust suppressant binders and systems for application were used in a futile attempt to control blowing dust from the idle half of the tailings pile. In early 1992, it was noticed that dust problems were worst just before switching sides. During the first three months after filling a side, there was little dust generated. Fresh tailings formed a crust as the surface dried which held up well to wind erosion until it was broken up by rain or physical action.

Based on this information, the tailings pile was divided into six sections to reduce the time that large areas of the tailings surface were idle. When one of the three sections on a side was filled (while leaving excess volume in the other two), the slurry was diverted to the other side. Work on the full section began immediately with berm building begun as soon as the surface could support the dozers. Cycle time was reduced from eight months to about three months and blowing dust from the dam was nearly eliminated. This also reduced the area covered by the free water pond during a given water cycle.

Minimizing the free water pond size and maximizing tailings decant are important water conservation techniques, but must be accomplished consistent with air quality permit requirements for the mines. Mines should be encouraged to continue to improve management of their tailings free water ponds by increasing the number of decant sites if possible, continuing to investigate alternative tailings dust control approaches, and continuing to manipulate tailings to minimize the free water surface.

4.5.4 Leach Pad Wetting

Cyprus Sierrita is leaching over eight million square feet of dump and heap area. Solution application rates vary from one to four gallons per minute of leach solution per 100 square feet of surface area. Over 29,000 AF/YR is being applied to the leach area, the majority of which is continuously recycled in the leach circuit.

Ponding of leach solution on leach dumps is generally not desired in the dry climate of Arizona because of increased evaporation. Also, where ponding occurs there is a possibility of channeling solution into areas of greater permeability which results in poor solution distribution through the leach area and lower copper recovery.

There are several different types of solution distribution systems used in the mining industry for leaching. These include flooding, soaker hoses, rotary sprinklers, fixed sprinklers, wobbler sprinklers and drip emitters. Application rates are governed by the size and porosity of the leach material and grade control of the solution exiting the leach area. Cyprus Sierrita has experimented with various distribution systems, including drip emitters. However, drip emitters proved unsatisfactory due to the clogging of filters by recycled leach solution. Cyprus is currently generally using wobbler type sprinklers.

For purposes of estimating evaporation from leach dump surfaces, it is assumed that evaporation proceeds at the same rate as pond evaporation plus an additional seven percent due to the sprays. This accounts for about four percent (1,049 AF in 1995) of the solution being applied to the leach areas, about 3.8 percent of 1995 ground-water withdrawals. Mines should be encouraged to continue to evaluate new solution distribution systems to reduce evaporation losses.

4.5.5 Mine Dust Control

An in-pit crusher is being constructed at ASARCO Mission. This installation will discharge waste rock onto conveyors that will convey the material out of the pit, reducing truck haulage. Estimated water use for haul road dust control is 500 AF per year. The reduction in haul road truck traffic due to the new conveyors is estimated to be 10 percent to 15 percent, reducing haul road dust control watering requirements by 50 to 75 AF per year, about 0.5 percent of the 1995 ground-water withdrawals.

Cyprus Sierrita currently uses conveyors to transport ore to the mill. Waste rock is hauled by truck. Estimated water use for dust control and on haul roads in 1995 was 225 AF.

Mines in the Tucson AMA have evaluated various dust suppressants to reduce water used for dust control. Efforts to identify effective dust suppressants should continue. Use of dust suppressants may require review by ADEQ.

4.6 STORM WATER RUNOFF AND DEWATERING

Rainfall and surface water drainage contained in tailing piles replaces groundwater pumpage to the extent it enters the free water ponds and is decanted for reuse at the mill. This is also true of rainwater collecting in the pits and removed as part of dewatering efforts. Cyprus Sierrita is increasingly retaining and reusing additional storm water runoff for makeup water at the mine. An added incentive to storm water retention is the benefit of avoiding discharge of water off site which is subject to storm water management regulations under the federal NPDES permit system. Pit dewatering may include rainwater, groundwater seepage from the side or bottom of the pits or ground water pumped from dewatering wells. Dewatering supplied 742 AF of makeup water at the ASARCO Mission Complex in 1995. Both water sources should be investigated further at the mines as possible sources of additional makeup water.

4.6 SUMMARY

Mine operations were reviewed to determine if additional ground water conservation could be achieved. Areas identified as having additional conservation potential should be addressed in the process of developing Third Management Period requirements for the metal mines. While conservation measures beyond those specified in the Second Management Plan are not currently required by ADWR, the mines have incorporated some of these measures and are planning to incorporate others in the near future. It is generally less expensive for the mines to reclaim water from existing uses than to pump more ground water. Conservation is, therefore, beneficial to the mines as well as to the AMA. In some cases additional conservation cannot be achieved due to current technical and cost limitations. These areas should continue to be reviewed and improved as new technologies emerge.

Tailings transport is one of the major water uses at the mines. Increasing tailings density, converting tailings transport piping to HDPE material and pumping tailings to the tailings dam instead of gravity feeding them, result in ground water savings. HDPE piping material is being used to replace existing pipe and will be used in construction of the new tailings facility No. 4 at ASARCO Mission. Cyprus Sierrita will need to commence pumping of tailings in the next several years as their tailings pile surface gets too high to continue to gravity feed tailings. Both mines are currently achieving tailings transport densities above ADWR requirements, and appear capable of increasing these densities over the next few years due to these changes.

Tailings pond management is a major factor in water use efficiency at the mines. While the amount of water retained in tailings is largely beyond the control of mine operators, seepage from underneath tailings ponds can be reduced by depositing the fine-grained portion of the tailings (slimes) on top of the native soil before delivering tailings loads to these areas. The area of free water ponding on tailings piles is controlled using decant towers and barge pumps. Multiple decant towers can reduce the free water surface. Minimizing the free water surface must be accomplished consistent with air quality requirements for the mines.

Other mine water uses represent conservation potential in some but not all cases. Evaporation from open reservoirs and tailings thickeners represents less than 0.3 percent of water use at the mines and does not justify the cost of installing evaporation control. Water may be conserved on leaching piles by continuing to test delivery methods other than the current sprinkler system. Water retention in leach piles is largely beyond the control of the mine operator. The use of conveyors to transport materials out of the pit can save water on road dust control, and is being practiced at one mine and planned for another. Rainfall, surface water drainage, and dewatering water are additional sources of water at mines. These sources are being developed to some extent and should be examined for further potential ground water savings.

5.0 CENTRAL ARIZONA PROJECT (CAP) WATER USE BY MINES

The use of CAP water by mines in Tucson AMA would reduce ground-water withdrawals. This section of the report discusses the availability of CAP water, its quality and compatibility with mine processes and the cost of acquiring and delivering CAP water to the mines.

5.1 CAP WATER

5.1.1 CAP Project

Colorado River water is divided among the seven Colorado River Basin states in accordance with the "Law of the River", a complex series of interstate agreements, congressional acts, contracts and U.S. Supreme Court decisions. Under the Law of the River, the lower basin states of California, Arizona and Nevada are entitled to 7.5 million acre-feet (MAF) of mainstream Colorado River water annually. Of the 7.5 MAF allocated to the lower basin, California gets 4.4 MAF, Arizona gets 2.8 MAF and Nevada gets 0.3 MAF. In times of shortage, California and Nevada and all other Arizona users are entitled to their full allocations before any water is available to the CAP. The CAP is literally last in line for water from the river.

The CAP is designed to bring approximately 1.5 MAF of Colorado River water per year to Pima, Pinal and Maricopa counties. CAP carries water from Lake Havasu on the Colorado River near Parker Arizona to the southern boundary of the San Xavier Indian Reservation southwest of Tucson. It is a 336-mile long system of aqueducts, tunnels, pumping plants and pipelines that lift the water nearly 2,900 feet in elevation. It is the largest single resource for renewable water supplies in the state. The project was completed in 1993.

The CAP system is divided into three aqueducts: the Hayden-Rhodes Aqueduct (Parker to Phoenix), the Fannin-McFarland Aqueduct (Phoenix to Casa Grande) and the Tucson Aqueduct. There are a total of 14 pumping plants along the aqueduct. Nine of these are located on the Tucson Aqueduct. Major CAP features are shown on Figure 5-1.

The CAP was built by the U.S. Department of Interior, Bureau of Reclamation. Allocation of CAP water among users is the responsibility of the Secretary of the Interior. The Secretary requested that ADWR develop recommended allocations for non-Indian municipal and industrial (including mining) users. These recommendations were accepted in 1983. CAP water is allocated to 85 M&I users, 12 Indian communities and 23 non-Indian agricultural districts.

CAWCD is a state agency formed specifically to operate and maintain the system and to repay the federal government the cost of construction of the project. CAWCD is authorized, among other things, to enter into subcontracts with water users in the CAP service area for delivery of CAP water.

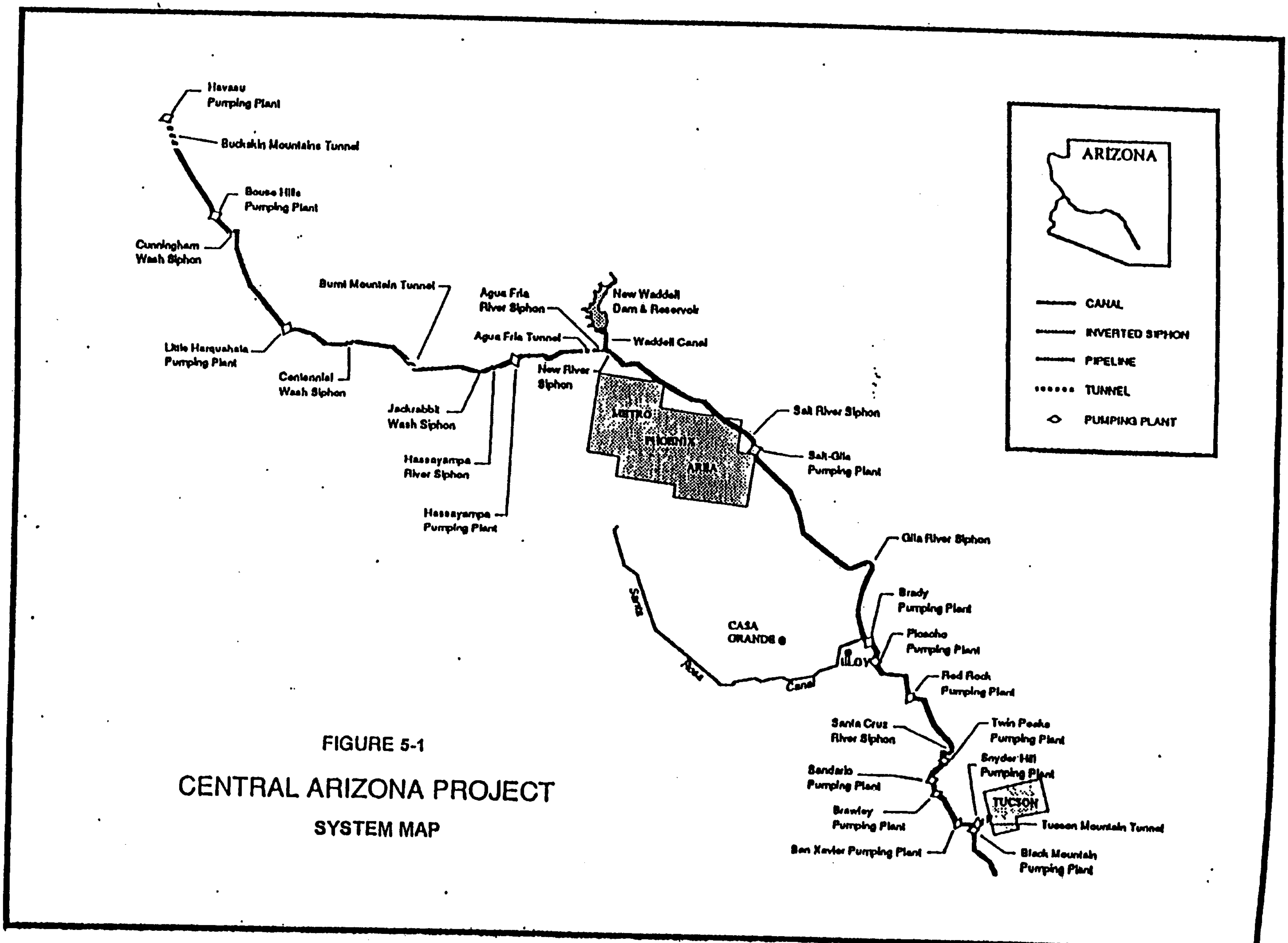


FIGURE 5-1

CENTRAL ARIZONA PROJECT

SYSTEM MAP

CAWCD 5/90

The point of delivery of CAP water to the Tucson AMA mines would be at the CAP terminus located near the intersection of Pima Mine Road and Interstate 19. Approximately 77,000 AF/YR of CAP water is theoretically available at the CAP terminus. The southernmost pumping plant (Black Mountain) lifts CAP water to the Black Mountain Reservoir at an elevation of 2,865 feet. The terminus is located at 2,785 feet, yielding an operating water pressure of approximately 35 pounds per square inch (psi) at the terminus.

5.1.2 Availability and Cost of CAP Water Supplies

There are several possible mechanisms for the mines to obtain CAP water. Availability and cost of CAP sources are discussed in the following subsections.

5.1.2.1 CAP Municipal and Industrial Allocations

In 1982, before the CAP canal was completed, water users in the state were given the opportunity to enter into subcontracts for CAP allocations. Recommended allocations to M&I users by ADWR were presented to the Department of Interior. A total of 640,000 AF were recommended for allocation to M&I users, including 29,157 AF for Tucson AMA metal mines, as shown in Table 5-1 (ADWR, 1982).

The Tucson AMA mine allocations were projected to start at 29,157 AF in 1985 and to decrease to 18,332 AF by 2034. However, Tucson AMA mines either declined to enter into contracts or, in one case, entered into and later terminated a contract for CAP water. Current contracts for CAP water in the Tucson AMA total 215,463 AF. These contracts consist of the City of Tucson's allocation of 148,420 AF, 38,333 AF for Indian use, 14,613 AF for water companies and irrigation districts, and 14,000 AF for the State Land Department (ADWR, 1996a).

Table 5-1, Status of Tucson AMA Metal Mine CAP Allocations

Tucson AMA Metal Mine	Projected Schedule of Demand in 1982 (AF/YR) 1985	2034	Final Status of CAP Allocation
ASARCO Mission Mine (now part of ASARCO Mission Complex)	4,161	0	Contract declined
Cyprus Pima (now part of ASARCO Mission Complex)	7,263	5,339	Contract signed then terminated
Duval (now Cyprus Sierrita)	11,628	8,549	Contract declined
Anamax Twin Buttes (now Cyprus Twin Buttes)	6,105	4,444	Contract declined
TOTAL	29,157	18,332	

Source: Federal Register, 1983

Costs for M&I Users The CAWCD establishes contracts for and manages the delivery of CAP water. The most recent capital charges and delivery rates for multiple classes of CAP water were approved by the CAWCD Board of Directors in November 1996 (CAWCD, 1996). Those rates relevant to possible CAP use by the mines have been tabulated (Tables 5-2 and 5-3). For M&I users with CAP subcontracts ordering CAP water, delivery rates have been set at $67/AF for 1997. An additional capital charge of $39/AF must be paid on the entire allocation regardless of whether CAP water is delivered. Total cost for 1997 M&I users is $106/AF.

Table 5-2, Cost Components of 1997 Rates for CAP Water

Cost Components	1997	1998	1999	2000	2001
Municipal & Industrial (M&I) Capital Charges Paid on full allocation regardless of water deliveries, not included in delivery rates	$39/AF	$48/AF	$48/AF	$54/AF	$54/AF
Water Delivery Costs					
Fixed OM&R $44.6 M fixed Operation, Maintenance and Repair (OM&R) costs divided by 1,250,000 AF of projected deliveries = $36/AF. This amount is collected on all ordered water whether delivered or not	$36/AF	Determined annually			
Pumping Energy $38.4 M pumping energy costs divided by 1,250,000 AF of projected deliveries = $31/AF. This amount is collected only for water actually delivered	$31/AF	Determined annually			
TOTAL WATER DELIVERY COSTS	$67/AF				
TOTAL COST	$106/AF				

Source (CAWCD), 1996

Table 5-3, 1997 CAP Water Rate Schedule

USER CATEGORIES AND QUALIFICATIONS	DELIVERY RATES 1997	1998	1999	2000	2001
Municipal & Industrial (M&I): These rates apply to M&I subcontractors. For M&I users who are not subcontractors, a capital charge is added and CAWCD creates an Excess M&I contractor rate for "as available" water	$67/AF	$71/AF	$82/AF	$87/AF	$91/AF
M&I Incentive Recharge: A special program offered to M&I subcontractors only. They must have valid ADWR permits and must gain recharge/storage credits from this activity. The CAWCD Board has approved this program through 1999. (Rate is pumping energy component plus $5 contribution towards fixed OM&R).	$36/AF	Same for 1998 and 1999			
Federal: For federal purposes including Indians, USBR construction water, etc.	$67/AF	Determined annually			
Arizona Water Banking Authority: Water purchased by the Arizona Water Banking Authority. It is available for scheduling after all other schedules have been filled. (Rate is pumping energy component plus $5 contribution towards fixed OM&R).	$36/AF	Same for 1998			

Source: CAWCD, 1996

Entities with M&I CAP allocations are one possible source for CAP water for ground-water savings arrangements. The price paid for CAP water by the mines in such an arrangement would be determined in negotiations between the partners of the ground-water savings arrangement. Currently, the City of Tucson charges farmers participating in ground-water savings programs from $6/AF to $15/AF based in part on electrical costs the farmers pay to pump ground water, which are sometimes subject to preferential rates. An M&I incentive price has been approved through 1999 for cases where allocated M&I CAP water is used for recharge. The incentive price is $36/AF. The entity buying this class of water must gain recharge or storage credits through an ADWR permitted facility. This rate is available for entities supplying allocated CAP water for both direct recharge and ground-water savings facilities.

5.1.2.2 Excess CAP Water

The volume of "excess" CAP water available from year to year varies, and is composed of the CAP water left over after long-term subcontractors and Indians have received their yearly orders for water. For M&I users who do not have CAP allocations, but who wish to purchase excess CAP if it is available, CAWCD adds a capital charge of $39/AF to the $67/AF delivery rate for a total delivered charge of $106/AF. Approximately one million AF/YR of excess CAP water is currently available.

5.1.2.3 Arizona Water Banking Authority(AWBA)

As discussed in Section 2.1.3, the AWBA will be obtaining CAP water for recharge throughout the state. The AWBA can participate in both direct recharge and ground-water savings arrangements in order to increase ground-water supplies for future withdrawal during times of CAP shortage. CAWCD supplies CAP water to the AWBA following fulfillment of all other contracts for CAP water.

The 1997 CAWCD price for CAP for water delivered to the AWBA is $36/AF. The AWBA in turn provides this water to entities for direct use in lieu of ground-water pumping at a $21/AF rate.

5.1.2.4 CAP Reallocations

Because of declined contracts around the state, 66,000 of the original 640,000 acre-feet of M&I CAP allocations was never contracted for and is available for reallocation. Proposed recommendations for reallocation of this supply were made by ADWR in 1994, but the process has not moved forward due to unresolved CAP repayment issues between the Department of Interior and CAWCD which could affect reallocation of this water. There is currently no water for Tucson AMA mines in the proposed recommendations for reallocation. (ADWR, 1994). The reallocation process could theoretically be reopened to include Tucson AMA mines, however.

5.1.2.5 Relinquishment or Exchange

For entities with CAP M&I subcontracts who wish to transfer a subcontract for CAP to another entity, ADWR has established a policy regarding the process for transfers which went into effect in August 1996 (ADWR 1996b). A transfer may include assignment, sale, lease or relinquishment of a CAP M&I subcontract for more than one year. The Department reviews requested transfers to determine the potential impacts of the redistribution of water and makes recommendations to the Secretary of Interior regarding transfers. Requests for transfer are reviewed for consistency with water management objectives including the dependability of water supplies, consistency with AMA goals, a preference for near-term use of CAP water, financial capability to pay project costs, and minimizing long-term overdraft. Priority is given for transfers that remain in the same AMA. In recent years a number of entities with CAP allocations have, for various reasons, relinquished or leased their allocations. Included are irrigation districts, Indian tribes and cities.

In 1992 the Bureau of Reclamation purchased the CAP allocation of the Harquahala Valley Irrigation Distinct for $1,050 per AF to satisfy Indian water right claims. The City of Scottsdale has or is in the process of acquiring some or all of the CAP water allocations of Prescott, Nogales, Meyer, Camp Verde, Cottonwood, Rio Rico, and the Yavapai-Prescott Indian Tribe. The price paid for this water is in the range of $1,080 to $1,100 per AF. In 1995 the Ak Chin Indian Tribe gave an option to the Del Webb Corporation to lease 6,000 to 10,000 AF of its surface water entitlement for 100 years. The price paid for this leased CAP water was $ 1,200 per AF plus $53 to $83 for each acre foot actually used.

The above prices are for the right to long-term (100+ years) use of CAP water. In addition to the cost of acquiring the rights to the water, users must, in most cases, also pay the capital, OM&R and energy costs of CAP water use.

5.1.3 CAP Water Quality

Water in the CAP aqueduct is surface water. While the primary source is the Colorado River, the aqueduct also contains water from the Agua Fria River via New Waddell Reservoir (Lake Pleasant), a storage reservoir located on the Hayden-Rhoades Aqueduct west of Phoenix. The quality of water delivered by the CAP is different than the ground water currently being used by mines in the Tucson AMA. The quality is also more variable, both annually and over wet and dry cycles on the Colorado River watershed.

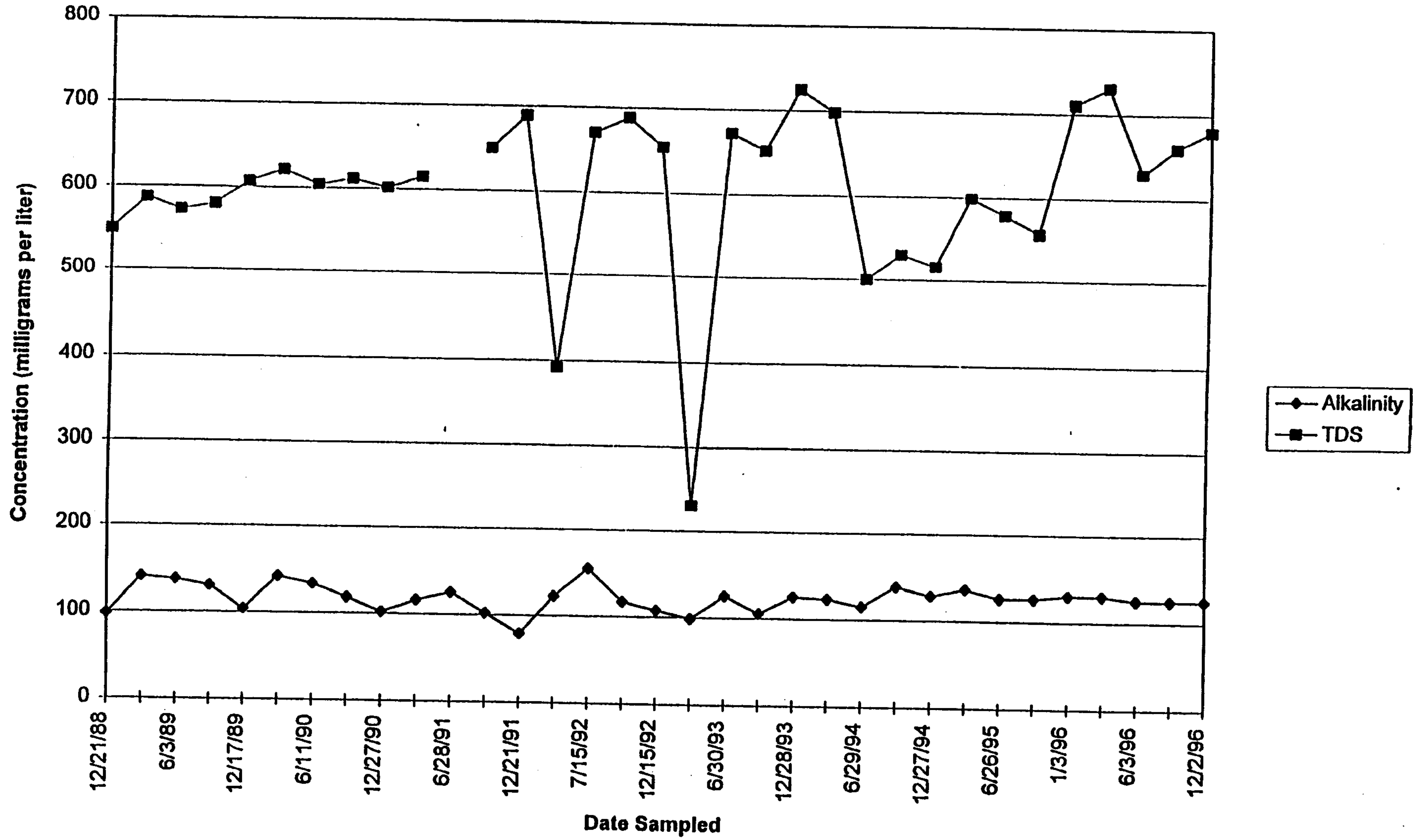
The U.S. Geological Survey has been collecting inorganic water quality data at several points in the aqueduct since 1987. The southernmost long-term sampling location is near Chandler (Mile 252), 84 miles upstream from the CAP terminus. Major inorganic CAP water quality parameters at Mile 252 for 1987-1996 are given in Table 5-4. Graphs of total dissolved solids (TDS) and alkalinity are shown on Figure 5-2. Dissolved oxygen (DO) and total suspended solids (TSS) are shown on Figure 5-3.

Table 5-4, CAP Water Quality at MP 252, 1987-1996

Parameter	Maximum	Minimum	Mean
pH (units)	9.0	8.0	8.4
Dissolved Oxygen	15.3	6.6	9.3
Total Organic Carbon	4.8	2.5	3.6
Sulfate	310	39	245
Hardness (mg/l $CaCO_3$)	339	110	278
Alkalinity (mg/l $CaCO_3$)	154	79	121
Total Dissolved Solids	730	230	612
Suspended Sediment	1,850	0	83

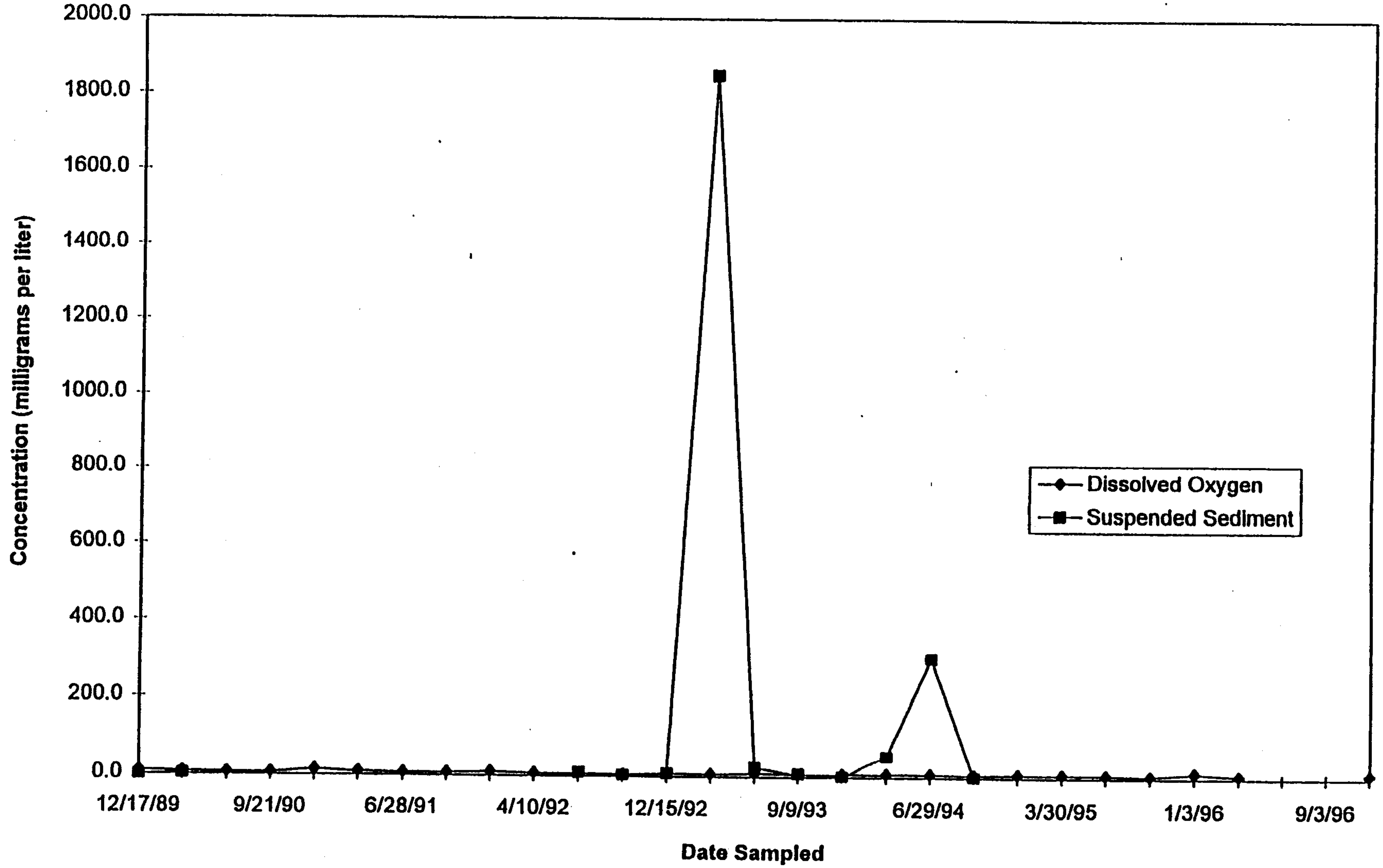
Note: All results are in milligrams per liter (mg/l) unless specified otherwise.

CAWCD started sampling water in the aqueduct on a monthly basis in 1996. In addition to many of the inorganic parameters measured by the U.S. Geological Survey, CAWCD sampling also included organic parameters. Total organic carbon (TOC) is an indicator of the level of organic material in CAP water. The Tucson Aqueduct has been shut down at Twin Peaks since 1993 due to a decision by the City of Tucson to temporarily halt delivery of CAP water. Therefore, the most recent reliable water quality data for the Tucson Aqueduct is available only as far south as the Brady Pumping Plant, located approximately 84 miles upstream from the CAP terminus. TOC for the Brady Pumping Plant is shown on Figure 5-4. Inorganic water quality at the Brady Pumping Plant is given on Table 5-5. Figure 5-5 presents the monthly values of alkalinity and TDS at the Brady Pumping Plant.



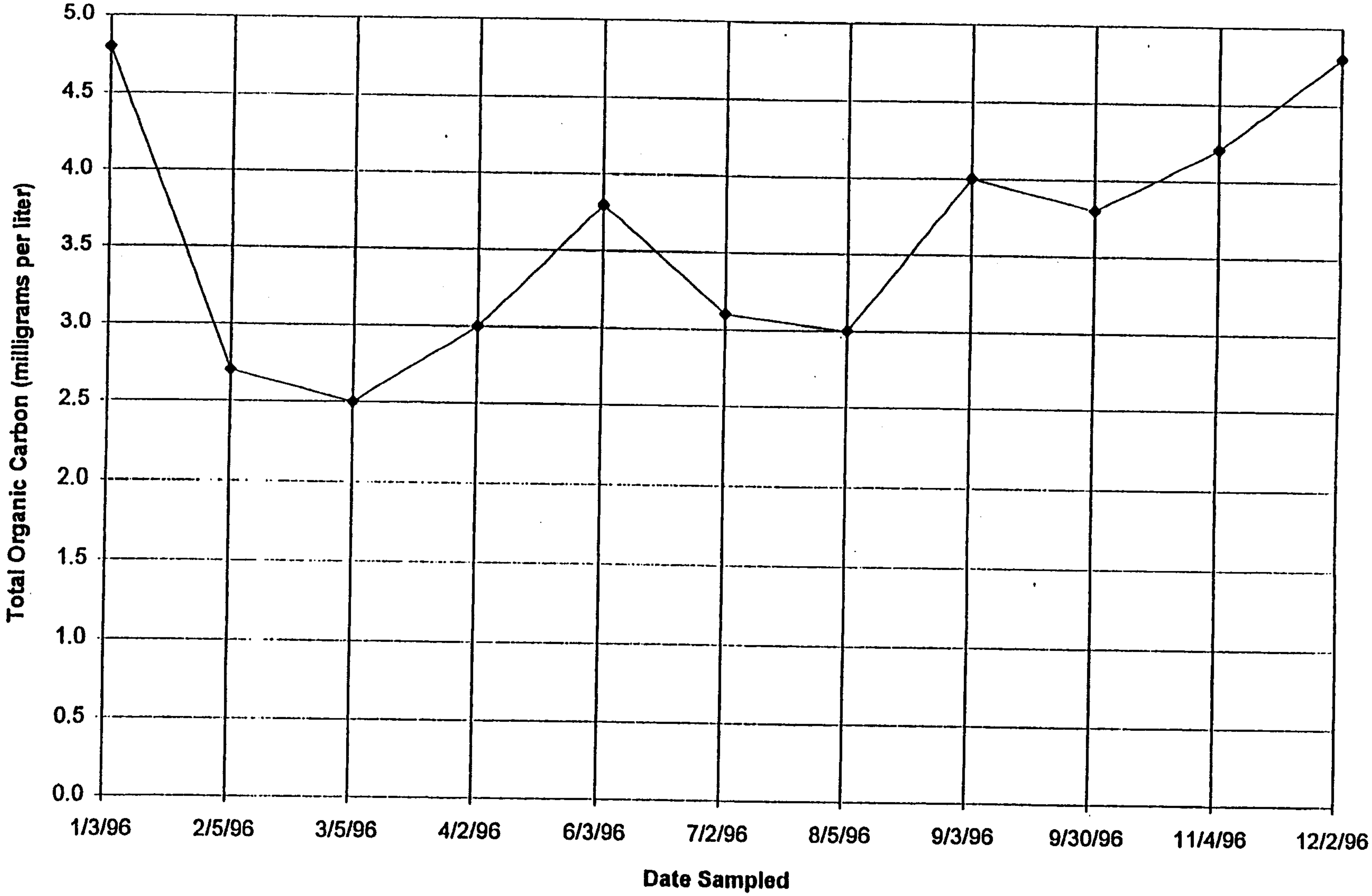
BRADY-1.XLS, Chart4

FIGURE 5-2
CAP Water Alkalinity and TDS at Mile 252, 1987 - 1996



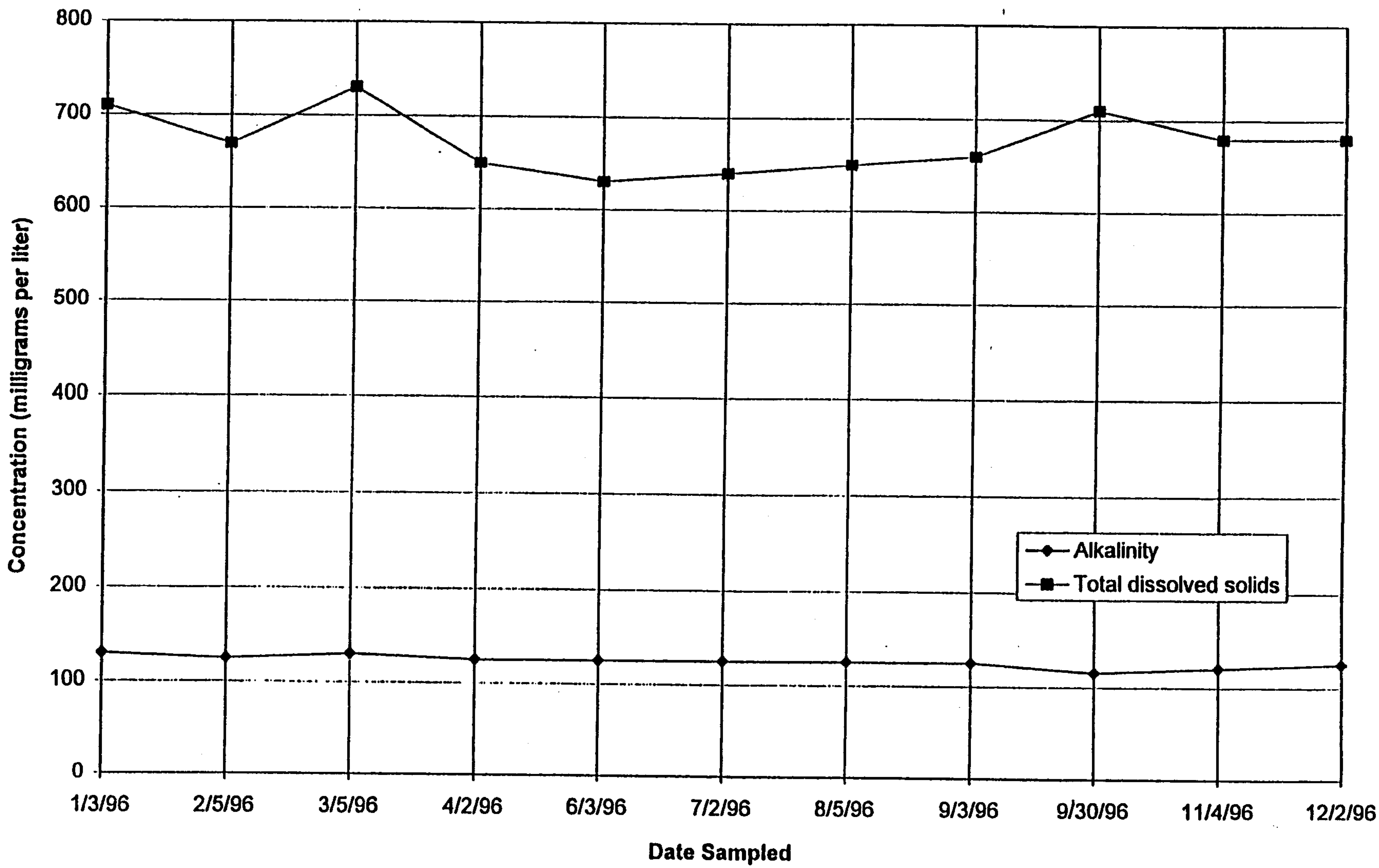
BRADY-1.XLS,Chart3

FIGURE 5-3
CAP Water DO and TSS at Mile 252, 1987 - 1996



BRADY-1.XLS, Chart1

FIGURE 5-4
TOC at Brady Pumping Plant, 1996



BRADY-1.XLS, Chart2

FIGURE 5-5
Alkalinity and TDS at Brady Pumping Plant, 1996

Table 5-5, CAP Water Quality at Brady Pumping Plant, 1996

Constituent	Maximum	Minimum	Mean
pH (units)	8.9	8.1	8.5
Dissolved Oxygen	15.3	8.4	10.8
Total Organic Carbon	4.8	2.5	3.6
Calcium	83	69	76.
Magnesium	34	30	32
Hardness (mg/l $CaCO_3$)	339	301	322
Alkalinity (mg/l $CaCO_3$)	130	115	125
Total Dissolved Solids	730	630	674
Suspended Sediment	NA	NA	NA

Note: All results are in milligrams per liter (mg/l) unless specified otherwise

These data indicate the variability of CAP water quality. The plots of TDS and TSS at mile 252 show the impact of flood flows on aqueduct water quality. The Bill Williams River empties into the Colorado River just upstream of the CAP intake at Parker. In the spring of 1993 the river flooded and aqueduct TDS declined from approximately 650 mg/l to 230 mg/l (Figure 5-2). Total suspended solids increased from less than 10 mg/l to over 1,850 mg/l in the same time period (Figure 5-3). In the summer of 1994 when the Aqua Fria River experienced high flows, aqueduct TDS dropped from approximately 700 mg/l to 500 mg/l. In 1996, TDS at Brady varied from 630 mg/l to 730 mg/l over a period of less than two months (Figure 5-5). TOC varied from 2.5 mg/l to 4.8 mg/l over a similar period (Figure 5-4). The variability at Brady is less than can be expected over a longer period of sampling due to the fact that 1996 was a year in which no flood flows to the aqueduct occurred.

Salinity (TDS) of the Colorado River is forecast to increase over time. With currently planned salinity control efforts, average TDS at Parker is projected to increase to approximately 780 mg/l by 2015. (Colorado River Basin Salinity Control Forum, 1993).

5.1.4 CAP Reliability

The CAP is subject to periods of reliability shortages and interruptions. CAWCD has defined two categories of reliability shortages: long-term and short-term. Long-term reliability shortages are those due to Colorado River water shortages or catastrophic events. Short-term reliability shortages are those due to planned maintenance and unplanned emergencies.

As noted in Section 5.1.1, the CAP is last in line to receive Colorado River water during shortage periods, e.g. when there is insufficient water in the river to meet the demands of all water right holders. During periods of shortages, minimum diversions will be made to the CAP aqueduct. Studies indicate that about 800,000 AF/YR of the total capacity of 1.5 MAF/YR would be available to CAP users under shortage conditions. Municipal and industrial (M&I) allocations could be reduced by as much as 25 percent of their normal delivery (Bureau of Reclamation, 1994).

The CAP Aqueduct capacity is decreased as water is delivered to users along its length. At Lake Havasu its capacity is 3,000 cubic feet per second (cfs). This is reduced to 2,250 cfs at the beginning of the Tucson Aqueduct (Brady Pumping Plant). At the end of the system (Black Mountain Pumping Plant) the capacity is 200 cfs. Design of the system has resulted in different levels of reliability for the Tucson Aqueduct versus the rest of the system.

The five large pumping plants on the Hayden-Rhoades and Fannin-McFarland Aqueducts have multiple pumps and two discharge lines. This configuration allows for the continued operation of these plants while maintenance is being performed on one or more pumps in a pumping plant. The Tucson Aqueduct, with its smaller pumping plants, was designed with the assumption that a storage facility would be built at the end of the aqueduct (terminal storage), making dual discharge lines unnecessary. The nine pumping plants on the Tucson Aqueduct, therefore, have a single discharge line. This means that when a plant's discharge line is out of service, flow in the aqueduct downstream of the plant is interrupted.

A terminal storage facility has not yet been constructed and there is some disagreement between the responsible parties over the size and configuration of an appropriate facility. Until such a facility is in place and, depending on its capacity even after it is built, the Tucson Aqueduct may be subject to more outages than the rest of the CAP.

The Bureau of Reclamation has estimated the anticipated frequency and duration of short-term service interruptions on the Tucson Aqueduct (Bureau of Reclamation, 1994). These are given in Table 5-6.

Table 5-6, Anticipated Short-Term Tucson Aqueduct Outages

Duration of Outage (Days)	Maintenance Outage	Emergency Outage
Less than 1	None Planned	1-8 per Year
1-4	1 per Year	1-5 per Year
5-30	1 per Year *	0-3 Every 10 Years
31-47	None Planned	0-3 Every 10 Years
48-365	None Planned	0-2 Over 50 Years
More than 365	None Planned	Unlikely

*Some procedures are expected to require more than 30 days to complete. However, these are expected to be staged so as to be performed over 2 or more 30-day periods.

As can be seen by the above table, CAP water cannot be relied upon as a continuous source of supply without a terminal storage facility and/or a backup supply.

5.1.5 CAP Water Delivery System

CAP water used by the mines would be pumped from the CAP terminus in pipelines to the mines. Location of the mines relative to the CAP terminus is shown on Figure 5-6. This figure also shows the location of proposed pipelines to the mines.

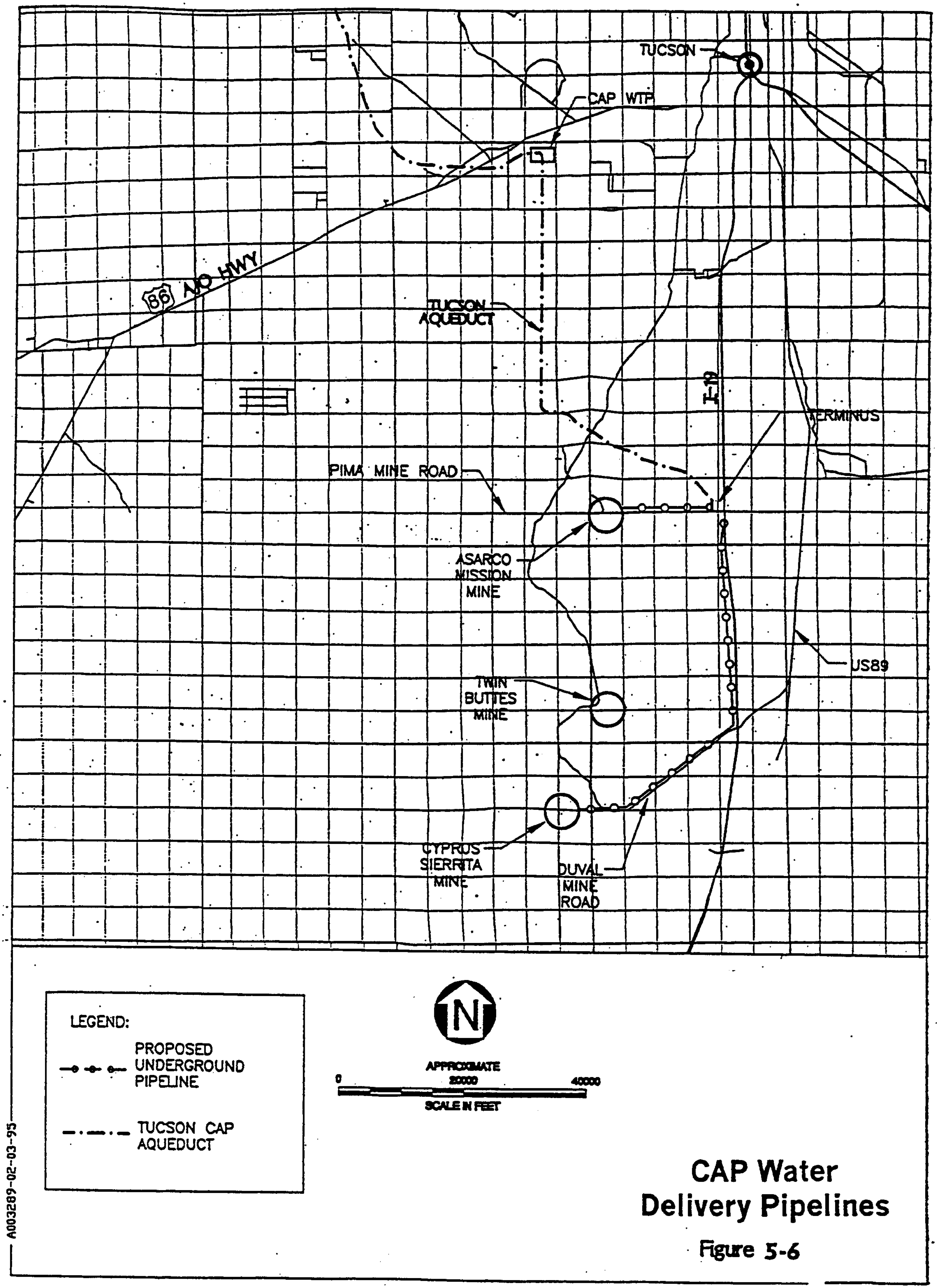
A conceptual plan to transport CAP water from the CAP terminus to each mine is discussed in the following paragraphs. Estimated conceptual level costs are also presented. The analysis assumes that CAP water usage by the mines would be confined primarily to the mill and leach circuits. While CAP water has a higher suspended solids content than ground-water it is not anticipated that CAP water will have to be filtered for use in the mill and leach circuits. Both of these circuits use reclaimed water mixed with ground water. Suspended solids in the reclaimed water do not appear to have adversely affected its use for milling or leaching. Cost estimates presented in this section, therefore, do not include the cost of a filtration plant. Details of the delivery system cost estimates are presented in Appendix B.

5.1.5.1 ASARCO Mission Complex

CAP water used by the ASARCO Mission Complex would be delivered to the planned 1,000,000 gallon tailings facility No. 4 reclaim water sump located between the tailings facility and Pima Mine Road. From the planned tailings facility No. 4 reclaim sump the water would be pumped to the mill reservoir, approximately 4.5 miles to the west and 700 feet higher in elevation.

The cost of the above facilities is dependent upon the volume of CAP water used. It is assumed that ASARCO Mission would continue to pump sufficient ground water to maintain a capture zone for potential seepage from the tailing facilities. The amount of ground-water pumpage required is unknown. However, for purposes of this analysis it is assumed that 3,000 AF/YR would continue to be pumped from current production wells. This water would also be used for domestic and some industrial uses. The difference between total makeup water demand (13,753 AF/YR) and continued ground-water withdrawal is approximately 10,000 AF/YR. This 10,000 AF/YR would be CAP water used in the mill circuit.

Since CAP water would be pumped to tailings facility No. 4 reclaim sump, both CAP water and reclaimed water would be pumped in the same pipelines to the mill water reservoir. Only that portion of the pump and pipeline cost required to carry the CAP water is included in the cost estimate. Estimated capital cost for pumps and pipelines to deliver CAP water to the mill is $4.2 million (1997 dollars). Operation and maintenance costs are estimated to $0.27/1,000 gallons or $88.00/AF.



CAP Water Delivery Pipelines

Figure 5-6

5.1.5.2 Cyprus Sierrita

The distance from the CAP terminus to the mill at Cyprus Sierrita is approximately 17 miles. The elevation difference is approximately 1,000 feet.

Cyprus Sierrita's total makeup water requirement in 1995 was 30,627 AF. Of this amount 6,537 AF were pumped from the tailings facility interceptor wells. It is planned to increase these wells in the near future to a total capacity of about 10,000 AF/YR. On this basis, the potential CAP water usage by Cyprus Sierrita is estimated to be approximately 20,000 AF/YR.

The estimated cost of pumps and pipelines (excluding land right of way costs) is $12 million (1997 dollars). Operation and maintenance costs are estimated at $167 AF.

The foregoing is the estimated cost if Cyprus Sierrita is the only CAP water user in the Green Valley area. However, several other entities have expressed interest in using CAP water, including FICO, Green Valley Water Company, Community Water Company and the City of Tucson (Upper Santa Cruz Water Users Group). If one or more additional entities were to use CAP water the cost of delivery facilities could be shared. Given its relative proximity to the CAP terminus, ASARCO Mission is likely to benefit less from cost sharing than Cyprus Sierrita.

5.2 IMPACT OF CAP WATER ON MINE OPERATIONS

5.2.1 Water Quality Compatibility

Water quality of the ground water currently being utilized by the mines is discussed in Sections 3.1.3 and 3.2.3. CAP water quality is presented in Section 5.1.3. Comparison of mean values of key parameters in the three water sources is given in Table 5-7.

Table 5-7, Comparison of Ground Water and CAP Water Quality

Parameter	ASARCO Mission Ground Water	Cyprus Sierrita Ground Water	CAP Water
pH	8.03	7.55	8.4
Alkalinity	131	148	121
Hardness	108	744	278
Sulfate	88	583	245
TDS	317	1039	612
TOC	NA	NA	3.6
Suspended Solids	NA	NA	83

All units in mg/l, except pH.
NA - Not Analyzed

With the exception of pH, alkalinity, TOC and suspended solids, the mean quality of CAP water is intermediate between ground water being utilized at the ASARCO Mission and Cyprus Sierrita mills. CAP water is slightly more basic than the ground water. While total organic carbon and suspended solids were not analyzed in the ASARCO Mission and Cyprus Sierrita samples, both parameters are typically very low in ground water. As noted in Section 5.1.3, the above CAP water quality data are from Mile 252, approximately 84 miles upstream from the CAP terminus. While some variation in quality due to evaporation between these two points can be expected, it is not anticipated to be significant.

Recovery of copper and molybdenum minerals by flotation is a chemical process. Most flotation circuits are operated at approximately 30 percent solids. This means that about 70 percent of flotation feed is water. Flotation reagents such as lime for pH control, collectors for mineral collection and frothers for froth control are added in small quantities to the feed water to optimize recoveries.

Mill water consists of roughly one-half reclaim water from thickeners and tailings dam and one-half makeup water. The reclaim portion of the water is partially conditioned by carry back of the lime and other reagents. Makeup water requires additional reagents to properly condition it for flotation. Variations in the makeup water quality will affect the quantities of reagents required. Current reagent costs are approximately $3 to $5 million per year. A 10 percent variation would cost $300,000 to $500,000 per year.

The operation of a mill to maximize mineral recoveries is an empirical process. Mill operators and mill metallurgists have developed a protocol for types of reagents and addition rates required to achieve the best results to optimize mineral recoveries. These protocols have been developed over time through constant metallurgical testing. Any chemicals introduced into a process at the mine such as chemical binders used on haul roads for dust control, new solvents, cleaning agents etc. are always tested in the metallurgical laboratory to evaluate any impact on flotation recoveries. Sometimes even small quantities of different chemicals can adversely affect recovery.

The economic impact of changes in flotation recovery is significant. Table 5-8, gives the value of copper recovered at the ASARCO Mission Complex for variations in the recovery percentage.

Table 5-8, Economic Impact of Variations in Flotation Recovery ASARCO Mission Complex

Asarco Mission Complex	Copper
Tons per day	63,000
Feed grade, %Cu	0.65
Lbs. of Cu in feed/day	819,000
1% Recovery variation (lbs./day)	8,190
Annual value of:	
1%/yr @ $1/lb	$2,989,350
5%/yr @ $1/lb	$14,946,750
10%/yr @ $1/lb	$29,893,500

Table 5-9, gives the values of copper and molybdenum recovered at the Cyprus Sierrita mill for variations in the recovery percentage.

Table 5-9, Economic Impact of Variations in Flotation Recovery Cyprus Sierrita

Cyprus Sierrita	Molybdenum	Copper
Tons per day	110,000	110,000
Feed grade, % Mo, Cu	0.029	0.29
Lbs. of Cu in feed/day	63,800	638,000
1% Recovery variation (lbs./day)	638	6,380
Annual value:		
1%/yr @ $1/lb	$925,640	$2,328,700
5%/yr @ $1/lb	$4,628,200	$11,643,500
10%/yr @ $1/lb	$9,256,400	$23,287,000

Given the empirical nature of mill recovery optimization, metallurgical testing of CAP water is required to assess the impact of using CAP water. Some metallurgical testing has been performed by the ASARCO Mission Complex, however, the results of these tests were not made available to the study team. Cyprus Sierrita has indicated a willingness to conduct tests, but these had not been initiated at the time of this report.

In a 1983 study at the University of Arizona, CAP water, ground water and effluent were used in a laboratory flotation cell to assess the impact of these water sources on copper and molybdenum flotation recoveries (Chu, 1983). The results of this study, for CAP water and ground water are given in Table 5-10.

Table 5-10, Copper and Molybdenum Recovery Using CAP Water and Ground Water

Water Source	% Cu	% Mo.
Ground water	92.0	87.8
CAP Water	91.4	86.1

This study indicated that using CAP water instead of ground water decreased copper recovery by 0.6 percent and molybdenum recovery by 1.7 percent. The study concluded that lower recoveries were probably due to the somewhat higher organic content of CAP water, 3.32 mg/l versus 1.17 mg/l for ground water.

These data indicate that the impact on copper recovery may be minor, while the effect on molybdenum recovery could be more significant suggesting that mines that recover molybdenum as well as copper, such as Cyprus Sierrita, may find it more difficult to use CAP water in their mill circuit.

Unfortunately, the study does not present chemical analysis of either the CAP water or ground water used. It is not possible, therefore, to assess how representative the study results are of current water quality conditions. Perhaps most importantly, the study did not assess the impact of variations in CAP water quality, as a single sample of Colorado River water (from Lake Havasu) was collected for use in the study. A full assessment of the impact of CAP water on mineral recovery will require metallurgical testing of a sufficient number of CAP water samples to encompass expected variations in water quality.

It should also be noted that ASARCO Mission and Cyprus Sierrita will likely continue to pump some ground water. This ground water would dilute any CAP water used and reduce the TOC content of water delivered to the mill.

Copper leaching circuits are much less sensitive to the quality of make up water than are milling operations. Over 90 percent of leach solutions are recirculated from the extraction circuits back to the leach dumps. Sulfuric acid is added to the leach solutions and they pass through large dumps that act as filters. The Cyprus Sierrita leach circuit should not be adversely affected by CAP water.

5.2.2 Reliability

The mines operate on a 24-hour, 365 day-per-year basis. It is essential that a continuous source of makeup water be available. Currently, this is provided by multiple ground-water wells and onsite reservoirs. If one or more of the wells need maintenance or repair there is sufficient capacity in the remaining facilities to ensure a continuous supply.

As noted in Section 5.1.4, the CAP project cannot provide an uninterruptable water supply. The mines are unable, therefore, to rely on CAP water as the sole source of supply. It will be necessary to maintain some or all of the mines' existing wells and distribution systems to supply water during periods of CAP water unavailability. As noted in Section 5.1.5, even if CAP water is used the mines will continue to pump some wells to comply with requirements to contain tailings seepage water.

5.2.3 Switching Between Water Sources

Switching between CAP water and ground water will result in water of a different quality being delivered to the mill storage reservoirs of the mines. Mill operators may need to adjust reagent addition rates to maintain mineral recovery efficiencies.

Maintenance outages are known in advance and there is sufficient time to phase in the change in water quality. The mixing ratio of CAP water and ground water can be changed gradually, allowing the mill operator to adjust to the change in water quality. Emergency outages may present greater problems for the mill operator, depending on where flow in the aqueduct is terminated. The Black Mountain Operating Reservoir (BMOR) at the Black Mountain Pumping Plant (the last pumping plant in the system) has a capacity of 200 AF. The aqueduct also acts as a storage reservoir that can be used to supply CAP water for blending with ground water during an emergency outage. The amount of water available depends on where in the system the outage occurs. A minimum of one to two days of supply is estimated to be available to the mines under emergency outage conditions.

5.3 SCENARIOS FOR MINE CAP WATER USE

There are several means by which CAP water could be made available to mines in the Tucson AMA. This section discusses scenarios for obtaining the legal right to CAP water and estimates the cost to obtain the water including capital, operation, maintenance, repair, energy and other costs. In order to facilitate comparison of costs, all scenarios assume that ASARCO Mission would use 10,000 AF/YR of CAP water and continue pumping 3,000 AF/YR of ground water, while Cyprus Sierrita would use 20,000 AF/YR of CAP water and would continue to pump approximately 10,000 AF/YR of ground water (see Section 5.1.5).

Capital and operating costs used in this report are all in 1997 dollars. In order to compare the cost of various CAP water use scenarios over the estimated life of the mines (30 years), the present value (PV) of both the capital and operating costs for each cost component was computed. A discount rate of three percent per year, representing the difference between the cost of money and inflation was used.

5.3.1 Components Common to All Scenarios

Some components, and their costs, are common to all scenarios for obtaining CAP water. These are:

- cost of constructing and operating pipelines and pumps needed to transport CAP water from the CAP terminus to the mines,
- cost of maintaining a backup ground water system,
- cost of continuing to pump ground water for seepage control, and
- increased mill reagent usage and decreased mineral recoveries.

Costs of constructing and operating pipelines and pumps required to transport CAP water from the CAP aqueduct to the mines, were discussed in Section 5.1.5. The present value costs, in 1997 dollars, are $21,965,840 for ASARCO Mission and $79,429,438 for Cyprus Sierrita over the estimated 30-year life of the mines.

Cost to maintain the wells, pumps and pipelines to supply ground water to the mines when the CAP aqueduct is not in service is estimated at the current cost of maintenance, or $29 and $59 per AF for ASARCO Mission and Cyprus Sierrita, respectively. The 30-year present value cost for ASARCO Mission Complex is $5,920,585 and $23,682,349 for Cyprus Sierrita.

Continuing to pump ground water for seepage control is based on the current cost of pumping plus withdrawal fees and totals $88/AF for ASARCO Mission and $116/AF for Cuprus Sierrita. This yields a present value cost of $5,397,586 for ASARCO Mission and $35,753,038 for Cyprus Sierrita over 30 years.

Unfortunately, costs associated with increased mill reagent use and decreased mineral recovery could not be estimated with the data available to this study and are not included in the costs presented in this report. Metallurgical testing of various blends of CAP water and ground water that simulate the probable water quality that would be delivered to each of the mines' mills are needed to develop these costs.

The sum of the above common costs (excluding mill reagent and mineral recovery costs) are $33,284,011 for ASARCO Mission and $138,864,825 for Cyprus Sierrita over the estimated life of the mines. The total estimated CAP water delivered (10,000 AF/YR)and continued ground-water pumpage (3,000 AF/YR) by ASARCO Mission over 30 years is 390,000 AF. For Cyprus Sierrita the amount is 900,000 AF (20,000 AF/YR CAP water and 10,000 AF/YR ground water).

The following subsections discuss the various options and associated costs for obtaining CAP water.

5.3.2 Subcontract with CAWCD

Mines in the Tucson AMA declined to enter into subcontracts with CAWCD during the initial allocation of CAP water (see Section 5.1.2.1). Approximately 66,000 AF/YR of M&I water is unallocated. While the process for allocating this water is uncertain, it is theoretically possible that the mines could apply for, and receive, an allocation.

By entering into a subcontract, the mines would have a firm right to CAP water, subject to its physical availability in the aqueduct. In exchange for this right, the CAP subcontract requires that the capital repayment portion of the cost of CAP water be paid even if no CAP is actually used. In addition, OM&R costs must all be paid on the water ordered in any year and energy costs must be paid on all water delivered.

To estimate the cost of subcontracted CAP water over the next 30 years, the following assumptions have been made:

- An average of 1.5 MAF/YR of CAP water is delivered
- M&I Capital charge is $54/AF
- OM&R charge is $30/AF ($44.6 M divided by 1.5 MAF/YR)
- Energy charge is $31/AF

In addition to entering into a subcontract for a firm allocation of CAP water, the mines could purchase excess CAP water on a year-to-year basis from CAWCD. Excess CAP water is that water which the system is capable of supplying but for which there is no current demand. CAWCD estimates that there will be excess CAP water available for 20 to 30 years. Almost one million acre feet per year of excess water is potentially available. (CAWCD, 1997). The cost of purchasing excess CAP water would be the same as for a subcontract allocation, however, the mines would not be responsible for paying the capital cost unless water was actually delivered.

The estimated present value cost of CAP water purchased through an allocation or as excess CAP water is given in Table 5-11.

Table 5-11, Cost of CAP Allocation or Excess CAP Water

Component	ASARCO Mission Cost ($)	Cyprus Sierrita Cost ($)
CAP Water	23,216,723	46,433,446
Common Costs (Transportation, Backup, and Intercept pumpage)	33,284,011	138,864,825
Total Cost*	**56,500,734**	**185,298,271**
Cost/AF**	145	206

*Cost of increased mill reagent use and decreased mineral recovery not included.
** Based on 30-year water usage of 390,000 AF for ASARCO Mission and 900,000 AF for Cyprus Sierrita.

5.3.3 Purchase or Lease from Existing Allottees

There are at least two entities in the Tucson AMA that are not likely to use their full CAP water allocation in the near future. The City of Tucson has the largest single allocation of CAP water, 148,420 AF/YR. In 1995, Proposition 200 was passed by Tucson voters, which prohibited the direct use of CAP water by the City for 5 years, unless it was treated to a much higher level than the City's existing treatment capability. The City currently used about 10,000 AF/YR for indirect recharge projects with farmers in 1995 and has plans to recharge additional CAP water in surface basins. However, Tucson is unlikely to be able to make full use of the remainder of its allocation in the near future.

The Tohono O'Odham Indian Nation has a total CAP water allocation of 37,800 AF/YR. There are no known active plans to use this water.

It is unlikely that these entities would relinquish their CAP water allocations, but they may be interested in leasing some of their allocation, especially if it were for a limited number of years.

The cost to lease water from either of these entities can only be determined by direct negotiation. For this study it is assumed that the price would be similar to the $1,100 AF received in recent transactions for long-term (100+ years) leases of CAP water, discounted for the shorter (30-year) lease period. A 30-year lease period discounted at three percent yields a cost of approximately $330 per AF. In addition, the mines would pay the capital, OM&R and energy cost of CAP water delivery. The 1997 costs of delivered CAP water is estimated to be $115/AF to the City and $67/AF to the Nation. Estimated present value cost of CAP water under this scenario is given in Tables 5-12 and 5-13. Estimates assume that lease costs are paid in year one.

Table 5-12, Cost of Leasing CAP Water from City of Tucson

Component	ASARCO Mission Cost ($)	Cyprus Sierrita Cost ($)
Lease from City of Tucson	26,516,723	53,033,446
Common Costs (Transportation, Backup, and Intercept pumpage)	33,284,011	138,864,825
Total Cost*	**59,800,734**	**191,898,271**
Cost/AF**	153	213

*Cost of increased mill reagent use and decreased mineral recovery not included.
** Based on 30-year water usage of 390,000 AF for ASARCO Mission and 900,000 AF for Cyprus Sierrita.

Table 5-13, Cost of Leasing CAP Water from Tohono O'Odham Nation

Component	ASARCO Mission Cost ($)	Cyprus Sierrita Cost ($)
Lease from Tohono O'Odham Nation	16,826,265	33,652,529
Common Costs (Transportation, Backup, and Seepage Intercept)	33,284,011	138,864,825
Total Cost*	**50,110,276**	**172,517,354**
Cost/AF**	128	192

*Cost of increased mill reagent use and decreased mineral recovery not included.
** Based on 30-year water usage of 390,000 AF for ASARCO Mission and 900,000 AF for Cyprus Sierrita.

5.3.4 Ground-water Savings Projects (Indirect Recharge)

As described in Section 2.1.1.3, ground-water savings projects have the potential to increase CAP water use in the AMA while reducing groundwater pumping. The mines could enter into an indirect recharge project with one or more entities. The most likely partners would be the Arizona Water Bank (AWBA) and the City of Tucson.

Under this scenario, mines would obtain groundwater savings facility permits and, in exchange for CAP water delivered, would reduce groundwater withdrawals on a gallon-for-gallon basis. The entity supplying the CAP water must obtain a Water Storage Permit and would receive long-term groundwater storage credits equal to the amount of CAP water delivered minus five percent (referred to as the "cut to the aquifer").

AWBA and the City of Tucson are participating in, or anticipate entering into, ground-water savings projects. The 1997 cost of CAP water delivered by the AWBA is $21/AF. The City of Tucson supplies CAP water for ground water savings projects with farmers for $6 to $15 /AF.

This scenario assumes that the mines would enter into a ground-water savings project with the City of Tucson and the City would supply CAP water at a cost of $15/AF, substantially less than the $115/AF cost to the City to acquire CAP water under their subcontract. The advantage to the City of supplying CAP water at a reduced cost to the mines is the City's accumulation of long-term CAP storage credits. The present value cost of this scenario is given in Table 5-14. These costs include ground-water withdrawal fees that must be paid in ground-water savings project arrangements.

Table 5-14, Cost of a Ground-water Savings Project with the City of Tucson

Component	ASARCO Mission Cost ($)	Cyprus Sierrita Cost ($)
CAP Water	3,028,268	6,056,536
Withdrawal Fees	807,538	1,413,192
Common Costs (Transportation, Backup, and Seepage Intercept)	33,284,011	138,864,825
Total Cost*	**37,119,817**	**146,334,553**
Cost/AF**	95	163

*Cost of increased mill reagent use and decreased mineral recovery not included.

** Based on 30-year water usage of 390,000 AF for ASARCO Mission and 900,000 AF for Cyprus Sierrita.

5.3.5 Cost of Continuing to Pump Ground Water

As noted in Section 2.1.1.1, use of CAP water by the mines is strictly voluntary under current ADWR regulations. The existing cost of ground water provides a basis, therefore, for assessing the likelihood that the mines would choose to use CAP water. Unit water pumping costs in 1997 for Cyprus Sierrita are reported to be $.32 per 1,000 gallons for power and $.18 per 1,000 gallons for maintenance. This totals $.50 per 1,000 gallons, or $163.00 per AF. This does not include amortization of capital costs for right of ways, pipelines, pumps and power systems. Unit costs were not available for the ASARCO Mission Complex. However, it is assumed that electric rates are comparable to Cyprus Sierrita. Pump lift is estimated to average about 700 feet, yielding a power cost of $0.17 per 1,000 gallons. Maintenance costs were assumed to be proportional to the pumping rate and are estimated to be $0.09 per 1,000 gallons, yielding a total 1997 operating cost of $ 84/AF.

In addition to energy and maintenance costs, ADWR and ADEQ assess fees on the ground water withdrawn. The ADWR withdrawal fee is $3 per AF. ADEQ assesses a Water Quality Act Revolving Fund (WQARF) fee of $2.12 per AF up to a maximum of $10,000 per year for each company. These fees when added to the energy and maintenance cost brings the 1997 cost of ground water to approximately $166/AF for Cyprus Sierrita and $88/AF for ASARCO Mission.

The present value cost of continuing to pump ground water over the 30 year estimated mine life is given in Table 5-15.

Table 5-15, Cost of Continued Ground Water Use

Component	ASARCO Mission Cost ($)	Cyprus Sierrita Cost($)
Ground Water Pumping	22,045,792	98,743,770
Withdrawal Fees	989,234	1,837,149
Total Cost	**23,035,026**	**100,580,919**
Cost/AF*	59	112

* Based on 30-year water usage of 390,000 AF for ASARCO Mission and 900,000 AF for Cyprus Sierrita.

5.3.6 Summary

Scenarios for use of CAP water by Tucson AMA mines include: 1) enter into a CAP subcontract or purchase excess CAP water, 2) lease CAP water from an existing CAP allotee, or 3) enter into a ground-water savings project with the City of Tucson. In order to compare the cost of these scenarios to the cost of ground water, the present value cost of pumping ground water over the life of the mines was calculated, as given in Table 5-15.

Table 5- 16 compares the present value cost of the three scenarios for CAP water use with the present value cost of ground water.

Table 5-16, Cost Comparison of CAP Water and Ground Water

Scenario	ASARCO Mission Cost ($)	Cost/AF	Cyprus Sierrita Cost ($)	Cost/AF
CAP Allocation/Excess	56,500,734	145	185,298,271	206
Lease CAP Water				
City of Tucson	59,800,734	153	191,898,271	213
Tohono O'Odham	50,110,276	128	172,517,354	192
Ground Water Savings Project	**37,119,817**	**95**	**146,334,553**	**163**
Ground-water Use	**23,035,026**	**59**	**100,580,919**	**112**

The least costly CAP water alternative to continued ground water use is a ground water savings project with the City of Tucson. The present value cost differential is $36/AF for the ASARCO Mission Complex and $51/AF for Cyprus Sierrita. These cost differentials are equivalent to approximately $0.002 per pound of copper produced at the ASARCO Mission Complex and $0.008 per pound of copper produced at Cyprus Sierrita. This cost differential does not include costs, if any, associated with increased mill reagent use or decreased copper or molybdenum recovery. These costs can only be determined following metallurgical testing with CAP water.

It should also be noted that the foregoing cost comparison is based on a number of assumptions and on currently available data regarding CAP costs. Many factors could significantly change the cost of individual CAP scenarios including different amounts of CAP water use, changes in CAWCD pricing, cooperative agreements with other users and negotiation between the mines and entities supplying CAP water.

6.0 CITED REFERENCES

Arizona Department of Environmental Quality, 1997. Personal communication with Linda Taunt February 7, 1997.

Arizona Department of Water Resources, 1982. Letter to James Watt, Department of Interior from Wesley Steiner, ADWR Director, January 18, 1982, page 5.

Arizona Department of Water Resources 1994. Memo from Rita Pearson, Director, to Persons Interested in CAP Reallocation, October 21, 1994.

Arizona Department of Water Resources, 1996a. State of the AMA Report - Tucson Active Management Area, April 1996.

Arizona Department of Water Resources, 1996b. Notice of Policy regarding Process for Transfers of Central Arizona Project Municipal and Industrial Water Subcontracts, August 23, 1996.

Arizona Water Banking Authority, 1996. Personal communication with Tim Henley, November 6, 1996.

Bureau of Reclamation, 1994. Preliminary Draft Environmental Impact Statement, Tucson Aqueduct System Reliability Investigation. October, 1994.

Central Arizona Water Conservation District, 1996. 1997 CAP Water Rate Schedule with notation that policy was adopted 10-10-96 and budget was adopted 11-07-96.

Central Arizona Water Conservation District, 1997. Personal communications with John Newman, November 6, 1996 through February 19, 1997.

Chu, C-L., 1983. Selected Tertiary Effluent Treatment Technologies for Reuse of Wastewater in a Mineral Flotation Process. M.S. Thesis, Civil Engineering Department, University of Arizona. 1983.

Colorado River Salinity Control Forum (CRSCF), 1993. Water Quality Standards for Salinity, Colorado River System, Final Report. 1993.

Federal Register, Vol. 48, No 58, March 24, 1983

Pima Association of Governments, 1996. Water Quality Permits in Pima County, July 1996.

Tucson Water, 1997. Personal communication with Dennis Rule and Karen Dotson. February 6, to 13, 1997.

APPENDIX A

SECOND MANAGEMENT PLAN CONSERVATION REQUIREMENTS FOR METAL MINING OPERATIONS IN THE TUCSON ACTIVE MANAGEMENT AREA

ARIZONA DEPARTMENT OF WATER RESOURCES
TUCSON ACTIVE MANAGEMENT AREA

OFFICIAL NOTICE OF INDUSTRIAL CONSERVATION REQUIREMENTS AND MONITORING AND REPORTING REQUIREMENTS - FOR ALL METAL MINING OPERATIONS

Pursuant to A.R.S. § 45-571.01, the Director of Water Resources hereby gives notice of the conservation requirements and monitoring and reporting requirements that apply to all metal mining operations in the Tucson Active Management Area.

Compliance with Second Management Plan conservation requirements must be achieved by January 1, 1992. Compliance with these conservation requirements must be maintained until the compliance date of any substitute conservation requirements prescribed in the Third Management Plan for Tucson Active Management Area.

SECOND MANAGEMENT PLAN CONSERVATION REQUIREMENTS

1. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, the following words and phrases used in Sections 2 through 7 of this Notice, unless the context otherwise requires, shall have the following meanings:

1. "Abandoned tail impoundment" means a tailing impoundment that a metal mining facility does not plan to use for additional disposal.

2. "Existing metal mining facility" means a large-scale metal mining and process facility that was engaged in mining and processing metallic ores as of December 26, 1984, or was substantially commenced as of December 26, 1984, and includes any expanded or modified portion of such a facility if the expansion or modification includes one or more new tailing ponds, new mill circuits or new wells, and was substantially commenced as of December 26, 1984.

3. "Large-scale metal mining and processing facility" means an industrial facility that mines and processes metallic ores and uses or has the potential to use more than 500 acre-feet of water per calendar year. For the purposes of this definition, the annual water use or potential annual water use includes all water from any source, including effluent, used or projected to be used within or by the facility, regardless of the nature of the use.

4. "New metal mining facility" means either:

A. A large-scale metal mining and processing facility that does not qualify as an existing metal mining facility, including any expanded or modified portion of such a facility if the expansion or modification includes one or more new tailing ponds, new mill circuits, new wells or new leaching facilities, or

B. Any expanded or modified portion of an exiting metal mining facility if the expansion or modification includes one or more new tailing ponds, new mill circuits or new wells, and was not substantially commenced as of December 26, 1984.

5. "Poor quality groundwater" means groundwater which the Director, in consultation with the Department of Environmental Quality, determines to have limited current or potential beneficial uses due to chemical, biological or radiological characteristics and costs associated with its use.

6. "Substantially commenced as of December 26, 1984" means, with regard to the construction, expansion or modification of a largescale metal mining and processing facility, that the owner or operator of the facility had obtained all pre-construction permits and approvals required by federal, state or local governments for the construction, expansion or modification of the facility by December 26, 1984, or had made a substantial capital investment in the physical on-site construction of the project in the 12 months prior to December 26, 1984.

2. Conservation Requirements for Existing Metal Mining Facilities

Except as provided in Sections 4 and 5, an existing metal mining facility shall comply with the following conservation requirements no later than January 1, 1992, and shall remain in compliance therewith during each calendar year thereafter until the first compliance date for any substitute requirements in the Third Management Plan:

1. Tailing Density

An existing metal mining facility shall transport tailing to the tailing impoundment area at the maximum density possible. The average annual density of the facility's tailing during transport shall be 45 percent solids by weight or greater.

2. Presliming/Interceptor Wells

An existing metal mining facility shall either:

A. Deposit a layer of tailing immediately up-slope from the free water level in each tailing impoundment. The tailing layer shall be 12 inches or more in thickness and shall be compacted in such a manner as to minimize soil surface permeability, or

B. Drill interceptor wells down-gradient from each tailing impoundment. The interceptor wells shall be designed, located and operated in such a manner as to intercept the maximum amount of seepage possible from each tailing impoundment.

3. Management of Water in Tailing Impoundments

An existing metal mining facility shall minimize the free water surface area in each tailing impoundment by:

A. Manipulating tailing which has been disposed of in a tailing impoundment, and managing new disposal of tailings in an impoundment, to maximize the depth of each tailing pond and minimize the free water surface area of each tailing pond.

B. Manipulating tailing which has been disposed of in a tailing impoundment, and managing new disposal of tailing in an impoundment, to create stilling basins that increase the rate of decant.

C. Using decant towers, barge pumps or sump pump to recycle water from each tailing pond back to the mill.

D. Expanding decant towers or barge pumping capacity where necessary to increase the capacity to recycle water from each tailing pond back to the mill.

E. Using, to the maximum extent possible, tailing pond water, rather than replacement water.

4. Capping Abandoned Tailing Impoundments

An existing metal mining facility shall cap each abandoned tailing impoundment with soil, rock waste, drought-tolerant vegetative cover or other equivalent material to minimize the quantity of water used for dust control purposes.

3. Conservation Requirements for New Metal Mining Facilities

Except as provided in Section 4 and 5, beginning January 1, 1992, or upon commencement of operation, whichever occurs later, and continuing thereafter until the first compliance date for any substitute requirements in the Third Management Plan, a new metal mining facility shall comply with the conservation requirements applicable to existing metal mining facilities prescribed in section 2, 3 and 4, and the following additional conservation requirements:

1. New Well Placement

A new metal mining facility shall design and install new wells to intercept the maximum amount of seepage possible from the facility.

2. New Tailing Impoundments

A new metal mining facility shall design and construct any new tailing impoundments to minimize seepage. The facility shall use decant towers to recycle water from each tailing pond back to the mill, and shall install interceptor wells down-gradient from each tailing impoundment. The interceptor wells shall be designed, located and operated to intercept the maximum amount of seepage from each tailing impoundment.

3. Tailing Density

A new metal mining facility shall design, construct and operate tailing transport systems to achieve the maximum tailing densities possible, but the average annual density of tailing during transport shall not be less than 50 percent solids by weight.

4. Plan For Using Latest Commercially Available Conservation Technology

At least three months prior to construction of a new metal mining facility, the facility shall demonstrate to the Director that the facility will use the latest commercially available conservation technology consistent with reasonable economic return by submitting to the Director a plan detailing:

A. A site evaluation, including a description of:

1. Hydrogeologic characteristics;

2. Availability and quality of water sources; and

3. Other applicable site specific characteristics.

B. The planned design, construction and operation of the facility, including a description of:

1. Ore type;

2. Proposed method of mining;

3. Proposed method of metal extraction; and

4. Commercially available technology.

The new metal mining facility may combine its plan for the use of the latest commercially available conservation technology with the long-range conservation plan required by Section 6.

4. Alternative Conservation Program

An existing or new metal mining facility may apply to the Director to use conservation technologies other than the technologies prescribed in Sections 2 and 3. The Director may approve the use of alternative conservation technologies if the Director determines that both of the following apply:

1. The owner or operator of the existing or new metal mining facility has filed with the Director a detailed description of the proposed achieved by the use of those technologies, and

2. The owner or operator of the existing or new metal mining facility has demonstrated to the satisfaction of the Director that the alternative conservation technologies will result in water savings equal to or greater than the savings that would be achieved by the conservation technologies prescribed in Sections 2 and 3.

5. Temporary Stay

An existing or new metal mining facility may apply to the Director for a temporary stay of any or all conservation requirements set forth in this Chapter if the facility expects to withdraw, on an annual basis, less than 50 percent of the average annual groundwater withdrawn by it during the preceding five calendar years. The Director may approve a temporary stay if the Director determines that both of the following apply:

1. The owner or operator of the facility has filed with the Director a conservation program and a compliance

schedule, or a modified conservation program and a compliance for the modified program, and

2. The owner or operator of the facility has demonstrated to the satisfaction of the Director that the compliance schedule requires the facility to make reasonable further progress toward compliance with the conservation requirements that the facility seeks to have stayed.

6. Long-Range Conservation Plan

By January 1, 1992, or three months prior to commencement of operations by the facility, whichever is later, each metal mining facility shall prepare a long-range water conservation plan. The plan shall include an evaluation of the use of the latest commercially available conservation technology consistent with a reasonable economic return. Prior to submitting the plan, each mining facility shall perform an analysis of the feasibility of applying the following conservation practices or technologies at the mine:

1. Using effluent, poor quality groundwater and Central Arizona Project water for mining and metallurgical needs.

2. Reducing tailing pond evaporation through the application of the latest commercially available technologies for minimizing evaporation from the ponds.

3. Minimizing water use for road dust suppression through the application of road binders.

4. Increasing tailing densities to 55 percent solids or greater by weight.

The metal mining facility may include any additional conservation techniques or technologies in the plan. The plan shall include a schedule of the approximate dates for implementation. The plan may be combined with the plan for the use of the latest commercially available conservation technology required by section 3, number 4.

7. Monitoring and Reporting Requirements

A. Water Measurement and Reporting

For the calendar year 1992, or the calendar year in which the facility commences operation, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Third Management Plan, each existing metal mining facility and each new metal mining facility and each new metal mining facility shall report the following information in its annual report required by A.R.S. § 45-632:

1. The quantity of replacement water from any source, including effluent, used during the reporting year for each of the following purposes: equipment washing, dust control, tailing revegetation, leaching operations and milling operations, as separately measured with a measuring device in accordance with the Department's measuring device rules, R12-15-901, et seq.

2. The quantity of water from any source, including effluent, recovered during the reporting year from each of the following: thickeners, leaching operations and pit dewatering, as separately measured with a measuring device in accordance with the Department's measuring device rules, R-12-15-901 et seq.

3. The quantity of makeup water from any source, including effluent, used during the reporting year for each of the following purposes: domestic use and transportation of tailings to tailing impoundments. These two quantities may be estimated.

4. The tons of ore milled during the reporting year.

5. The tons of ore during the reporting year stacked to heap leach.

6. The tons of ore vat leached during the reporting year.

7. The tons of material mined during the reporting year.

8. The average percentage of solids' weight in tailing transported to the tailing ponds during the reporting year.

B. Tailing Impoundments.

For the calendar year 1992, or the calendar year in which the facility commences operation, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute requirements in the Third Management Plan, each existing metal mining facility and each new metal mining facility shall determine the mathematical relationship between the average depth of the tailing pond water at the decant site and the average size of the free water surface area in each tailing pond during the year. To make that determination, the facility shall measure the tailing pond water depth at the decant site in each tailing pond at least once every 14 days. Each facility shall maintain current and accurate records of the tailing pond water depth for each tailing pond at the decant site in its annual report required by A.R.S. § 45-632

C. Contiguous facilities

A single annual report shall be filed for an existing metal mining facility and a new metal mining facility which are contiguous and owned by the same owner. The report shall describe the combined operations of the existing and new metal mining facilities in the reporting requirements specified in Subsections A and B above.

NOTICE ISSUED BY

Elizabeth Ann Rieke
Director

SMPNOT.MIN

APPENDIX B

CAP WATER DELIVERY SYSTEM COST ESTIMATES

2/13/97

CONSTRUCTION COST ESTIMATE INDUSTRIAL PROJECT

CLIENT:	AZ. Dept. Water Res.	PROJECT#	96-965
PROJECT:	90000LF Pipe Line	ISSUE DATE	13-Feb-97
LOCATION:	CAP To Sierrita	BY: MRB /SQ	
REV. No ________	REV. DATE ________	APPROVED ________	

Account #	DESCRIPTION	Hours	Labor	Materials	ConEquip.	Subcon	TOTAL
0	Mobilization	320	4160	500	3000	7500	15160
3	Fence					6000	6000
4.1	Excavation	5000	69000	0	138000	0	207000
4.2	Backfill/Screen	4300	56500	0	169500		226000
5.3	Concrete/4EA@50cy	1500	20000	20000	2500	7500	50000
5.5	Concrete Anchor Blks	400	5200	14800	0	0	20000
7.7	Pump Shelters					24000	24000
18	HDPE Pipe 30" SDR11	23000	299520	5967000	120000	0	6386520
18.1	CS Headers	640	6300	40000	0	0	46300
18.2	Valves @ Pump 36EA	864	12000	54000	0	0	66000
18.3	ISO Valves (4ea)	600	7800	50000	0	0	57800
18.4	Elect/Inst.	10000	150000	400000	12000	0	562000
18.5	Pumps/Motors 12EA	1728	22500	480000	0	0	502500
19	Demobilization	320	4160	0	3000	7500	14660
10	TOTAL DIRECT FLD	48672	659140	7026300	448000	52500	8185940
10.1	FLD.SUPER&SAFETY	8338	141260				141260
10.2	TOOLS & EQUIP				350000		350000
10.3	INSURANCE		52826			368	53194
10.4	FLD. PAYROLL & BURDEN		334286				334286
10.5	MISC. FIELD INDIRECT					85000	85000
10.6	PERDIEM		105682				105682
10.7			0				0
	TOTAL INDIRECT	8338	634054	0	350000	85368	1069422
	TOTAL FIELD COST	57010	1293194	7026300	798000	137868	9255362
11	HOME OFFICE					3%	277661
12	TOTAL FIELD						9533023
13	CONTINGENCY					5%	476651
14	ESCALATION						0
15	CONTRACT TAX						382711
	SUBTOTAL						10392385
16	FEE					10%	1039239
17	ENGINEERING					5%	519619
18	PROJECT MANAGEMENT						42000
19	CLIENT'S COST						11993243

2/13/97

CONSTRUCTION COST ESTIMATE INDUSTRIAL PROJECT

CLIENT:	AZ. Dept. Water Res.	PROJECT#	96-965
PROJECT:	47,500LF Pipeline	ISSUE DATE	13-Feb-97
LOCATION:	CAP To ASARCO	BY: MRB /SQ	
REV. No______	REV. DATE ______	APPROVED______	

Account #	DESCRIPTION	Hours	Labor	Materials	ConEquip.	Subcon	TOTAL
0	Mobilization	320	4160	500	3000	7500	15160
3	Fence					3500	3500
4.1	Excavation	2800	36400	0	73000	0	109400
4.2	Backfill/Screen	2100	27800	0	85000		112800
5.3	Concrete/2EA@50cy	750	10000	10000	1500	4000	25500
5.5	Concrete Anchor Blks	200	2600	7500	0	0	10100
7.7	Pump Shelters					12000	12000
18	HDPE Pipe 30" SDR11	12500	162500	3150000	65000	0	3377500
18.1	CS Headers	320	4200	20000	0	0	24200
18.2	Valves @ Pump 18EA	432	6000	27000	0	0	33000
18.3	ISO Valves (2ea)	300	4000	25000	0	0	29000
18.4	Elect/Inst.	5300	80000	250000	8000	0	338000
18.5	Pumps/Motors 6EA	864	12000	240000	0	0	252000
19	Demobilization	320	4160	0	3000	7500	14660
10	TOTAL DIRECT FLD	26206	353820	3730000	238500	34500	4356820
10.1	FLD.SUPER&SAFETY	4760	80160				80160
10.2	TOOLS & EQUIP				200000		200000
10.3	INSURANCE		28643			242	28884
10.4	FLD. PAYROLL & BURDEN		181608				181608
10.5	MISC. FIELD INDIRECT					47130	47130
10.6	PERDIEM		57172				57172
10.7			0				0
	TOTAL INDIRECT	4760	347583	0	200000	47372	594954
	TOTAL FIELD COST	30966	701403	3730000	438500	81872	4951774
11	HOME OFFICE					3%	148553
12	TOTAL FIELD						5100327
13	CONTINGENCY					5%	255016
14	ESCALATION						0
15	CONTRACT TAX						204757
	SUBTOTAL						5560101
16	FEE					10%	556010
17	ENGINEERING					5%	278005
18	PROJECT MANAGEMENT						30000
19	CLIENT'S COST						6424116