INSPECTION REPORT

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD - CENTRAL VALLEY REGION

WDS NUMBER: 5A322014001
NPDES#: CA0080110

Form Printed -> 04/05/93

DISCHARGER:

CALICOPIA CORPORATION
6754 S. 68TH E. AVE
TULSA ,OK 74133

CONTACT: ROGER BARRY
PHONE: 9184816139

FACILITY NAME:

WALKER MINE
20 MI E OF QUINCY ON CO RD 112
PORTOLA ,CA

CONTACT: ROGER BARRY
PHONE:

STAFF: WAC

ORDERS:

ORDER NUMBER	DATE ADOPTED	TYPE
90-031	900126	RAG
85-033	850125	NPD
90-030	900126	NPD

LAST INSPECTIONS:

DATE	TYPE	VIOLATION?
920303	A1	N
920422	A1	N
920610	A1	N
920730	A1	N
921130	A1	N

SCHEDULED INSPECTIONS: 9208A1 9303A1 9306A1

INSPECTION TYPE:

[X] 1. "A" TYPE COMPLIANCE (SAMPLING)
[ ] 2. "B" TYPE COMPLIANCE (NO SAMPLING)
[ ] 3. NON-COMPLIANCE FOLLOW-UP
[ ] 4. ENFORCEMENT FOLLOW-UP
[ ] 5. COMPLAINT
[ ] 6. PRE-REQUIREMENT
[ ] 7. MISCELLANEOUS

PROGRAM COMPONENT TASK NUMBER: 1101

NPDES INFORMATION:

INSPECTION AGENCY
[X] STATE
[ ] STATE/EPA JOINT

WAS THIS AN EPA SCHEDULED INSPECTION? Yes [X] No [ ]
(If Yes, EPA Form MUST be completed)

INSPECTION DATE: 930312 (Y Y M M D D)

INSPECTOR'S INITIALS WAC

CONTACT: N/A

INSPECTION SUMMARY (100 character limit): Download data logger, p = 15.9 psig or 36.7 feet. Samples at a few sites. Show 15 to 20 feet deep. tunnel failed at ≈ 250 feet.

ADDITIONAL COMMENTS:

	Cu	Zn	Fe	Cd	
portal -	1.4	0.076	pending	0.0008	mg/L
DC/48"Ø Culvert -	0.45	0.054	0.35	≤0.0005	"
Brown's Cabin -	0.15	0.096	2.0	≤0.0005	"
LGC/Far West -	0.071	0.02	0.81	<0.0005	"

WDR REVIEW: No

MONITORING PROGRAM REVIEW: No.

Was the discharger in VIOLATION at time of inspection? YES [ ] NO [X] PENDING SAMPLE RESULTS [ ] NOT APPLICABLE [ ]

(If yes, you MUST attach a completed violation input form.)

INSPECTOR SIGNATURE & DATE: 4/6/93

Reviewed By: DJM.

APR 14 1993

DATA ENTRY DATE:

United States Department of Agriculture
Forest Service
Plumas National Forest
159 Lawrence Street
P.O. Box 11500
Quincy, CA 95971-6025

BC
LWJM

Reply to: 2840

Date: January 5, 1994

Atlantic Richfield Company
C/O Mr. Lodwrick M. Cook, Chairman and CEO
515 S. Flower Street
Los Angeles CA 90071

Dear Mr. Cook:

Walker Mine, located on the Plumas National Forest in northeastern California, was owned and operated by Walker Mining Company from approximately 1919 to 1943. Moody's Industrial Manuals and reports by the California Bureau of Mines create a link between the Walker Mining Company and Anaconda Co. Our research indicates that when Walker Mine was in operation, controlling interest was owned by International Smelting and Refining Company, a subsidiary of Anaconda Copper Mining Company. Anaconda was purchased by your corporation in 1977.

The Walker Mine Tailings Pond, a part of the Walker Mine, and located on National Forest System lands, was placed on the Federal Agency Hazardous Waste Compliance docket (the "docket"), pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) under Title 42 of the United States Code, Section 9620 (c), (42 U.S.C. 9620 (c)) by unilateral U.S. Environmental Protection Agency (EPA) action in 1991. The site was docketed due to release of reportable quantities of copper and zinc as listed in 42 U.S.C. 9601 (14). Although the above referenced docketing action does not necessarily represent the Forest Service's position as to which sites are properly placed on the docket, nevertheless this action has occurred, and several other statutory actions have been set in motion.

Since the Walker Mine Tailings Pond is located entirely on National Forest System land, the surface land comprising the pond is administered by the USDA Forest Service, Pacific Southwest Region, Plumas National Forest. When Walker Mining Company is mentioned in the Moody's Industrial Manuals and reports by the California Bureau of Mines, statements such as "Controlling interest owned by International Smelting and Refining Company, a subsidiary of Anaconda Copper Mining Company" are made. Corporate research also indicates that Atlantic Richfield Company purchased the Anaconda Co. in 1977. Our records also indicate that the above mentioned "release" is directly related to mining operations at Walker Mine, including the tailings pond. Therefore, you are hereby notified that your corporation is jointly and severally liable as a Potentially Responsible Party (PRP) under 42 U.S.C. 9607(a) for all response costs, interest, and any natural resource damages (42 U.S.C. 9607(f)), which may be attributed to the above mentioned release, unless this release is exempt from liability due to the statutory defenses found at 41 U.S.C. 9607(b).

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From our review of this situation, and as a consequence of EPA's docketing action, I have reason to believe that the above mentioned release, and the threat of future releases, may be a threat to public health or welfare or the environment per Title 40, Code of Federal Regulations, Section 300.415(b)(2) (40 C.F.R. 300.415(b)(2)). In compliance with the Forest Service's role in protecting the public health and welfare, and because the Walker Mine Tailings, a product of operating the Walker Mine, is on National Forest System lands administered by the Plumas National Forest, I hereby inform you that, pursuant to that authority found at 42 U.S.C. 9604(a) and in Executive Order 12580, I have initiated a CERCLA "response" action to assess the above mentioned copper and zinc release. The Forest Service is the "lead agency" for all response actions occurring on National Forest System lands, as defined by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. 300.5. All response actions will be consistent with the NCP.

As this release occurred on a facility under the jurisdiction of a federal agency (the Forest Service), and although the Forest Service specifically denies any liability for said release, we conducted a timely Preliminary Assessment (PA) and submitted it to the EPA in 1991. A Site Investigation (SI) has also been conducted on the above mentioned release as set forth in 42 U.S.C. 9620. The Forest Service has also prepared a Remedial Investigation and Feasibility Study (RI/FS) plus a Proposed Treatment Plan and is in the process of preparing the CERCLA Record of Decision (ROD) in which the decision will be made whether or not to initiate any or all of the recommended cleanup actions. I, therefore, invite your participation in any CERCLA actions deemed necessary on this site by the Forest Service or other state and federal agencies.

Because this site was docketed, the PA was completed in 1991 and the SI was completed in 1993. We would be pleased to work with you on the treatment actions we will be implementing through the ROD. If you wish to participate in this process, please advise me, in writing of this decision by close of business on February 4, 1994. No response by that date will be construed as a negative response, and the Forest Service will conduct treatment actions approved by the ROD under its CERCLA authorities. However, as mentioned above, your respective corporation will still remain liable for all associated costs.

In addition, the California Regional Water Quality Control Board, Central Valley Region (the Board), has expressed concerns about the above mentioned releases to the waters of both Dolly Creek and Little Grizzly Creek. Contaminated water from the Walker Mine site enters Dolly Creek, thence Little Grizzly Creek after flowing across the tailings pond, where additional contamination is occurring. The Board considers the tailings pond material to be a hazardous waste. As part of our CERCLA response activities, we have conducted a "removal evaluation" (NCP: 40 C.F.R. 300.410) consisting of sampling and monitoring actions to ascertain the complete nature and extent of the hazardous material, including the identification of hazardous materials other than copper and zinc. Removal actions will be identified in the CERCLA Record of Decision. The decision whether or not to initiate any or all recommended cleanup actions will be made in the ROD.

By copy of this letter, I have advised EPA and the California Regional Water Quality Control Board of the above action, and that any cleanup action will comply with all substantive provisions of federal and state Applicable Relevant and Appropriate Requirements (ARARs), unless properly waived pursuant to the NCP.

Please provide a written response stating whether or not you plan to participate as requested above. Should you have questions, please contact Terry Benoit of this office at (916) 283-2050. If you wish to receive a copy of the site investigation, proposed plan, or any other documents concerning this project, Mr. Benoit will provide you with them.

Sincerely,

H. WAYNE THORNTON
Forest Supervisor

cc:
District Ranger, Beckwourth Ranger District

California Regional Water Quality Control Board
Central Valley Region
Attn: Bill Marshall
3443 Routier Road, Suite A
Sacramento, CA 95827-3098

U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

Calicopia Corporation
C/O Mr. Henry R. Barry, CEO
6754 South 68th East Avenue
Tulsa, OK 74133-1727

Office of General Counsel
Region 5
C/O Rose Miksovsky

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
COOPERATIVE AGREEMENT

Cooperative Agreement No. 1432-C0250003

Cooperator: California Regional Water Quality Control Board, Central Valley Region

Authority: P.L. 85-934

Project Title: California Mine Seals

Funding for this Agreement: $40,000 (FY 1995 funds)

Funding Authority: P.L. 103-332, Interior and Related Agencies Appropriation Act for FY 95, dated September 30, 1994.

Effective Date: Date the agreement is signed

Technical Project Officer: Russell Dix, Reno Research Center
Reno, Nevada 89512 (702) 334-6621

Program Manager: K. Wong

California Regional Water Quality Control Board, Central Valley Region	U.S. Department of the Interior Bureau of Mines
By: Dale Chapman 9/22/95	By: Janice L. Coffelt 9/29/95
Signature Date	Signature Date
Typed Name: Walt Pettit	Typed Name: Janice L. Coffelt
Title: Executive Director	Title: Contracting Officer

AGREEMENT

This agreement, made and entered into the date this agreement was executed by the U.S. Bureau of Mines, between the United States of America, acting through the Department of the Interior, Bureau of Mines (hereinafter referred to as the Bureau), and the California Regional Water Quality Control Board, Central Valley Region (hereinafter referred to as the Cooperator), witnesseth that it is agreed and understood as follows:

COOPERATION

The United States Government represented by the Director of the Bureau of Mines or her authorized designee and the State of California Regional Water Quality Control Board, Central Valley Region (Cooperator) mutually agree to conduct certain research work, as described in this Agreement. The research work to be conducted consists of installation of a monitoring well into the Walker Mine and continuous monitoring of the impounded water in the underground workings. The actual well installation procedure is to be performed by a licensed drilling contractor. Since the Cooperator has well-established procedures and personnel for awarding and inspecting contract work in California, the process of soliciting bids, awarding a contract for the well installation, and certifying job completion will be conducted by the Cooperator. Upon certification of job completion by the Cooperator, the Bureau will monitor, and sample, the impounded water in the underground workings, and will reimburse the Cooperator for the actual costs of the installation of the monitoring well, within certain limits that are specified in the later text of this agreement.

Section A - Statement of Work

1. Field Site

The field site selected for the monitoring well installation is the Walker Mine, located in Plumas County, California. Cooperator will obtain any necessary permission from landowners or from any other parties holding any property interest in the site so that the installation may proceed. If for any reason it becomes impractical to proceed at the selected site, an alternate site may be substituted by mutual agreement of the Bureau and Cooperator, if adequate funding is available to proceed at an alternate site.

2. Procurement Procedure and Funding for the Field Site Well Installation

Funding of $40,000 for the well installation will be provided by the Bureau and the balance will be paid by the Cooperator. The contract will specify that the well will be cased with 4-inch NPT

316 stainless steel casing purchased by the Bureau and given to the Cooperator in 1994.

Cooperator will solicit bids for installation of the well at the selected site, using Cooperator's established procedures for procurement. Cooperator will conform to all federal and state laws applicable to this procurement process, such as the laws on equal employment opportunity and applicable preferences for minority-owned small businesses.

Cooperator will award the contract to a qualified contractor (Contractor). Cooperator will make any needed determination as to qualification of any bidder. If there is a choice of qualified contractors with closely matched bids, the Bureau may give advisory input into the selection, but the actual selection of the contractor and award of the contract will be the prerogative of the Cooperator.

Upon completion of the job by the Contractor, Cooperator will notify the Bureau by letter that the job has been completed; such letter will include a complete breakdown of all billable items for the contract such as labor costs, equipment costs, material costs, Contract's administrative overhead, and mobilization-demobilization charges. Upon completion and acceptance, the Bureau will reimburse Cooperator.

3. Observation, Supervision, and Inspection of the Field Work

Supervision and Inspection of the field work will proceed according to the normal mechanisms and procedures of the Cooperator. Contractor will retain full responsibility for Contractor's operations and personnel. Cooperator will have the right and responsibility to inspect work in progress to determine that it conforms to the design specifications, and to inspect the completed job and to determine if and when the job can be accepted as complete. The Bureau will have personnel on site to observe and record the progress of the job for the purpose of future documentation; this observation may include videotape and photographs. Such personnel may include personnel from another agency that may be invited by the Bureau to assist in the Bureau's observations. The Bureau personnel or personnel invited by the Bureau will not interfere with or attempt to direct the progress of the job. If any design changes are requested by Contractor as the job progresses, the request for such changes shall be addressed to Cooperator. Cooperator shall determine whether any requested design changes are acceptable, with advisory input from the Bureau to Cooperator if such input is requested by Cooperator. Cooperator shall notify the Bureau in writing of any design changes that may be authorized, together with the reason for such changes.

4. Time Frame

A goal of this agreement is for the field work to begin during the Summer or Fall of 1995 and to be completed by December 15, 1995. Final acceptance of the field work shall be completed by December 31, 1995. In the event of delays, these dates may be extended by written agreement between the parties.

5. Additional Reclamation

Cooperator will assume responsibility for any necessary site reclamation. Examples of such additional reclamation for which Cooperator would have sole responsibility would include any additional final site reclamation such as emplacement of topsoil, reseeding, etc., and any installation of permanent warning signs, and/or fences at the site after the well is installed. The contract awarded to a licensed drilling contractor will include provisions for any necessary reclamation.

Section B - Government Involvement

The Bureau will be responsible for monitoring and inspection of the monitoring well. It will offer expertise and advice in the design of the well. The Bureau will reimburse Cooperator for the construction contract, up to the maximum amount for which the Bureau has agreed in this Agreement to be responsible.

Section C - Cooperator's Contribution

Cooperator will solicit bids and award a construction contract, through existing procurement procedures, to install a monitoring well at the selected site. Construction inspection, approval of any change orders requested by the contractor, and certification of job completion shall be the responsibility of Cooperator. Cooperator will assume responsibility for any additional final site reclamation, topsoil emplacement, reseeding, etc., after the well has been installed. Cooperator will obtain any necessary permission from landowners or other parties having a property interest in the selected site, and will ensure that the contract procurement procedure and the contractor's operations conform to all applicable provisions of federal law and California state law, with especial reference to Equal Employment Opportunity and to applicable job safety regulations.

Section D - Deliverables

The following is a summary of the deliverables due from each party to this agreement, as mentioned in the Description of Work:

1. Cooperator will deliver:

   a. A notice of the award of contract, giving the name of the Contractor, the scheduled time for beginning work, and the amount of the awarded bid.

b. A letter explaining any design changes that may from time to time be authorized by Cooperator.

c. Upon satisfactory completion of the job by Contractor, a letter stating that the job has been completed and itemizing Contractor's charges, paid by Cooperator; such charges shall be sufficiently documented by providing copies of the daily inspectors report and of certified payrolls, costs of mobilization-demobilization charges, and any other significant cost categories.

Section E - Agreement Administration Data

1. TITLE TO PROPERTY

Any and all property and equipment of whatever nature or kind furnished by either party in connection with work under this agreement is and shall remain the property of the party furnishing such property and equipment.

2. OWNERSHIP OF DATA AND RECORDS

All original notebooks, data sheets, record charts, graphs, or other records maintained by the Bureau which are kept during, or arise out of, the work done pursuant to this agreement shall be the property of the Bureau. Copies of such materials may be released outside the Bureau upon approval.

3. PUBLICATION

Both parties shall have the right to announce and publish the results, facts, or conclusions on any of the cooperative work. Each party will submit to the other party a draft of any proposed report or publication for review and comment, but in no case will either party abandon its right to publish information resulting from the expenditure of public funds or the use of public facilities. Joint publication or simultaneous announcement by the State and the Bureau is encouraged. Any announcement or publication shall expressly recognize and give credit in the text and on the title page to the cooperation of the other party.

4. OFFICIALS NOT TO BENEFIT

No Member or Delegate to Congress shall be admitted to any share or part of this agreement or to any benefit that may arise therefrom.

5. LIABILITY

To the extent allowable by State law, the Cooperator agrees to be responsible for its own acts and the results thereof, and will assume all risk and liability to itself, its agents or employees, for any injury to persons or property resulting in any manner from the conduct of its own operations and the operations of its agents or employees under this agreement and for any loss, cost or damages, or expenses resulting at any time from any and all causes due to any act or acts, negligence, or the failure to exercise proper caution, of or by itself or its agents, or its employees while occupying or visiting the premises under and pursuant to this agreement. Furthermore, the United States Government agrees to be responsible as to and under this agreement to the extent of and by the authority set forth in the Federal Tort Claims Act, as amended (28 U.S.C. 2671-80 (1976), and will have no other liability.

6. EQUAL EMPLOYMENT OPPORTUNITY

During the performance of this agreement, the Cooperator agrees as follows:

(a) The Cooperator will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The Cooperator will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. such action shall include, but not be limited to, the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Cooperator agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this Equal Opportunity clause.

(b) The Cooperator will, in all solicitations or advertisements for employees placed by or on behalf of the Cooperator, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(c) The Cooperator will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(d) The Cooperator will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(e) In the event of the Cooperator's noncompliance with the Equal Opportunity clause of this contract or with any of the said rules, regulations, or orders, this contract may be canceled, terminated, or suspended, in whole or in part, and the Cooperator may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, or by rule, regulations, or order to the Secretary of Labor, or as otherwise provided by law.

(f) The Cooperator will include the provisions of paragraphs (1) through (7) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The Cooperator will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions, including sanctions for noncompliance: Provided, however, that in the event the Cooperator becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the Cooperator may request the United States to enter into such litigation to protect the interests of the United States.

7. PAYMENT FOR SERVICES

The Cooperator agrees to provide certain services, the costs of which will be reimbursed by the Bureau. However, the Bureau will not be responsible for any costs incurred by the Cooperator prior to the execution of a formal procurement document.

8. TERMINATION

This agreement shall expire on December 31, 1995, but may be extended for additional periods by written agreement between the parties hereto, provided, however, that it may be terminated at any time by either party giving written notice of termination to the other party at least thirty (30) days prior to the date fixed in such notice. Upon termination of this agreement by the Bureau, the Bureau shall be responsible for reimbursement of those costs incurred or obligated by the Cooperator prior to receiving written notice of termination.

Where the operation of this agreement extends beyond the current fiscal year, this agreement is expressly conditioned and contingent upon the Congress making appropriation for necessary expenditure hereunder after such current year shall have expired. The Bureau agrees to seek sufficient funding to fulfill its obligations under this agreement. In case such appropriation as may be necessary to carry out this agreement is not made, the Cooperator hereby releases the Bureau from all liability for failure to perform due to the failure of Congress to make such appropriation.

9. ORDER OF PRECEDENCE

In the event of any inconsistency among the provisions of this cooperative agreement, the inconsistency shall be resolved by giving precedence in the following order: (a) this cooperative agreement document; (b) OMB Circulars; and (c) other provisions of the agreement whether incorporated by reference or otherwise.

10. ATTACHMENTS

#1 - Representations, Certifications and Other Statements of Offerors

#2 - OMB Circular A-87 (Cost Principles for State and Local Governments)

#3 - OMB Circular A-102 (Grants and Cooperative Agreements with State and Local Governments)

IN WITNESS WHEREOF, the parties hereto have made and executed this agreement as of the day and year first above written.

SER

WATER SURFACE DIVERSION
WALKER MINE

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PLUMAS COUNTY, CALIFORNIA

Call Neil Krutz
at WESTEC

WESTEC®

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WATER SURFACE DIVERSION
WALKER MINE
✦✦✦
PLUMAS COUNTY, CALIFORNIA

Prepared for:

California Regional Water Quality Control Board
3443 Routier Road, Suite A
Sacramento, California 95827-3098

Prepared by:

WESTEC®

WESTEC Project No. 19904
Report No. 764

November 1996

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1.0 INTRODUCTION AND PROJECT DESCRIPTION

The Walker Mine is an 800 acre inactive copper mine in east-central Plumas County approximately 15 miles east-northeast of Quincy and 20 miles northwest of Portola. The initial discovery of the Walker Mine was in 1904, with mine development initiated in 1915. There were two major periods of mining from 1916 to 1932. The deposit consists of five major orebodies ranging from 600 to 1,400 feet long and 10 to 100 feet thick, with a typical thickness on the order of 50 feet. The copper ore is a fine-grained dark hornfels metamorphosed during igneous intrusion into the sedimentary strata.

The mine is estimated to contain about 13 miles of tunnels and 3,500 feet of vertical shafts. Total void volume in the mine has been estimated to be as much as 543 million gallons although information generated as part of this study would imply a volume closer to 330 million gallons. Primary access to the mine is through a 3,000 foot adit penetrating a granitic intrusion that intersects the south orebody at the seventh or 700 level of the mine.

The mine is located in the upper end of the Little Grizzly Creek Basin. The basin covers an area of approximately 34 square miles and is about 10 miles wide at its widest point. The upper basin has terrain made up of rugged mountains and meadowlands. Elevations in the basin range from nearly 3,700 feet to 8,000 feet. The mine is at an elevation of approximately 6,180 feet.

Little Grizzly Creek Basin drainage flows to Dolly Creek and Little Grizzly Creek. Little Grizzly Creek is approximately 15 miles long with approximately 10 being impacted to some degree by the Walker Mine. The Walker Mine has surface drainage and portal drainage to Dolly Creek, a tributary to Little Grizzly Creek.

Average annual precipitation ranges from 50 inches on the higher western mountains to 25 inches in Genesee Valley. The corresponding 10-year, 24-hour storm event ranges from 6 inches to 4.5 inches. The mine site is subject to heavy snowfall in winter and is generally inaccessible to motor vehicles from November through April. Climate in the area is extremely variable and temperatures can have a large diurnal range as well as a large seasonal range.

Summer temperatures are warm, rarely exceeding 100°F at the lower elevation and in the low 90s at the highest elevations. The winters are relatively severe with below-freezing temperatures and heavy snowfall being common. Dirt roads traversing the drainage basin are closed throughout most of the late fall, winter, and early spring. The growing season in the area extends from early May to late September.

The Walker Mine was deactivated in 1941 and the first documented complaint concerning water quality was in 1955 by the Plumas County Board of Supervisors. Since its closure, the site has discharged acid and heavy metals directly into Dolly Creek and the groundwater. The discharge to surface waters has resulted in the elimination of aquatic life downstream in Dolly Creek and Little Grizzly Creek for a distance of approximately 10 miles. Only through dilution at the confluence with Indian Creek was the quality of these waters improved sufficiently for aquatic life. The California Regional Water Quality Control Board - Central Valley Region (Regional Board) began investigating specific pollutants discharging from the Walker Mine Site in 1957. These investigations indicated that the mine portal was a primary source of pollution in Dolly Creek and Little Grizzly Creek.

A secondary source of pollution is the non-point surface run-off from springs, rainfall, and/or snowmelt that has passed through mine waste piles and an unlined settling pond. Oxidation of pyrite and other sulfide minerals resulted in the production of acid and mobilization of heavy metals (acid rock drainage). Over the years the Regional Board has made numerous administrative attempts to correct the problem or direct that the correction be effected with no consistent success.

The first surface water diversions were installed around sinkholes during logging activity in 1969 but inspection in 1970 showed them to be largely ineffective. Additional diversion ditches were constructed during July and August 1981. All diversion facilities have been constructed as unlined ditches. Regional Board personnel have described significant loss of flow due to seepage from these unlined ditches as they traverse areas near the sinkholes or the zone on-line with the orebody between sinkholes. This implies a substantial infiltration loss into induced fracture systems associated with the observed subsidence and sinkhole development. It is our understanding that with the possible exception of one sinkhole in the Piute Adit area, all sinkholes appear to be stable and are not actively expanding at this time.

In November 1987, the Regional Board installed an engineered concrete mine seal 2,500 feet underground in the main 700 level adit of the mine. This seal has successfully prevented the direct discharge of acid rock drainage from the underground workings of the mine to surface waters in the Little Grizzly Creek and the Ward Creek watersheds. The mitigation measure has resulted in a 98 percent reduction of copper in Dolly Creek on a mass load basis. The performance of the seal is and will be continually monitored for effectiveness, leakage, and hydrostatic pressure. Surface water of Little Grizzly Creek and Ward Creek will also be monitored.

2.0 REVIEW OF CLIMATOLOGICAL DATA

The project site is located approximately 20 miles northwest of Portola, California and approximately 15 miles east-northeast of Quincy, California. The two closest temperature and precipitation recording stations are located in Portola and Quincy. Table 2-1 and 2-2 summarize the measured climatological data for these two sites over 44 years of record. These data are based on information available from the National Climatic Data Center (NCDC) and were retrieved using CD-ROM software entitled "NCDC Summary of the Day" by Earthinfo, Inc.

The precipitation for the 100-year, 24-hour; the 10-year, 24-hour; and the 2-year, 24-hour storm events are estimated to be 8.0, 6.0, and 4.5 inches, respectively, using the precipitation atlas for the State of California (NOAA, 1983).

TABLE 2-1
SUMMARY OF CLIMATOLOGICAL DATA
1948 - 1991 AT PORTOLA STATION

Station:	**PORTOLA**	**Latitude:**	**N39:48:00**	**ID:**	**7085**
County:	**PLUMAS**	**Longitude:**	**W120:28:00**	**Begin Date:**	**7/1948**
State:	**CA**	**Elevation:**	**4850**	**End Date**	**2/1991**

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
MAXIMUM DAILY TEMPERATURE (Fahrenheit)													
Day Average	41.7	46.6	51.2	59.3	67.9	77.4	86.0	84.4	78.3	67.6	52.7	44.1	63.4
Maximum for Month	51	57	60	68	76	85	91	92	86	76	63	55	66
Maximum for Year	1961	1991	1972	1949	1954	1977	1959	1981	1951	1952	1949	1958	1959
Minimum for Month	31	36	43	45	58	71	80	77	65	58	44	35	60
Minimum for Year	1949	1956	1952	1967	1977	1953	1987	1976	1986	1984	1985	1990	1989
MINIMUM DAILY TEMPERATURE (Fahrenheit)													
Day Average	17.4	20.2	24.0	27.4	32.5	37.6	40.6	39.1	34.9	28.9	24.0	19.1	29.0
Maximum for Month	28	30	32	33	37	43	47	45	39	34	31	29	33
Maximum for Year	1986	1963	1978	1990	1963	1977	1988	1958	1967	1979	1950	1981	1986
Minimum for Month	1	10	17	21	27	30	36	33	29	24	15	7	26
Minimum for Year	1949	1949	1952	1975	1976	1976	1961	1957	1971	1951	1959	1990	1949
DAILY & MONTHLY PRECIPITATION (Inches)													
Day Average	0.12	0.11	0.09	0.04	0.04	0.02	0.01	0.01	0.02	0.04	0.09	0.11	0.06
Maximum for Month	12.05	11.94	8.94	4.57	2.59	2.59	2.54	2.09	2.85	9.70	8.64	14.36	39.75
Maximum for Year	1969	1986	1974	1963	1971	1969	1952	1965	1986	1962	1983	1955	1983
Minimum for Month	0.08	0.04	0.23	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.60
Minimum for Year	1991	1988	1988	1952	1974	1986	1989	1988	1987	1986	1959	1989	1976

TABLE 2-1
SUMMARY OF CLIMATOLOGICAL DATA
1948 - 1991 AT PORTOLA STATION

Station:	**PORTOLA**	**Latitude:**	**N39:48:00**	**ID:**	**7085**
County:	**PLUMAS**	**Longitude:**	**W120:28:00**	**Begin Date:**	**7/1948**
State:	**CA**	**Elevation:**	**4850**	**End Date**	**2/1991**

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
Monthly Average	3.80	3.04	2.91	1.27	1.09	0.60	0.34	0.36	0.58	1.18	2.51	3.35	21.89
DAILY & MONTHLY SNOWFALL (Inches)													
Day Average	0.58	0.48	0.31	0.11	0.03	0.00	0.00	0.00	0.00	0.01	0.17	0.49	0.17
Maximum for Month	69.00	80.30	64.00	61.00	7.50	0.00	0.00	0.00	4.00	5.00	24.00	71.70	185.60
Maximum for Year	1952	1969	1967	1982	1971	1990	1990	1990	1971	1948	1985	1971	1952
Minimum for Month	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
Minimum for Year	1991	1991	1988	1990	1988	1990	1990	1990	1990	1990	1990	1990	1986
Monthly Average	17.81	13.38	9.63	3.11	0.89	0.00	0.00	0.00	0.10	0.30	5.12	15.24	74.76

TABLE 2-2
SUMMARY OF CLIMATOLOGICAL DATA
1948 - 1991 AT QUINCY STATION

Station:	QUINCY	Latitude:	N39:58:00	ID:	7195
County:	PLUMAS	Longitude:	W120:57:00	Begin Date:	7/1948
State:	CA	Elevation:	3410	End Date	2/1991

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
MAXIMUM DAILY TEMPERATURE (Fahrenheit)													
Day Average	45.7	52.4	56.7	65.1	74.1	83.2	91.0	89.8	84.0	72.8	56.1	46.0	69.5
Maximum for Month	55	67	64	74	82	90	95	96	91	84	65	55	71
Maximum for Year	1991	1991	1959	1959	1969	1987	1985	1967	1987	1988	1959	1976	1959
Minimum for Month	36	43	47	49	64	77	84	81	75	63	50	40	66
Minimum for Year	1949	1949	1952	1967	1977	1953	1983	1976	1986	1957	1964	1971	1955
MINIMUM DAILY TEMPERATURE (Fahrenheit)													
Day Average	21.4	24.9	27.9	30.6	36.0	41.2	42.5	40.4	36.1	30.4	27.5	23.6	32.4
Maximum for Month	30	35	34	37	43	46	48	49	43	38	36	32	34
Maximum for Year	1956	1963	1983	1965	1963	1969	1952	1990	1963	1963	1950	1955	1963
Minimum for Month	1	16	23	26	32	37	38	33	29	24	18	12	29
Minimum for Year	1949	1949	1955	1975	1953	1984	1955	1955	1954	1949	1959	1976	1955
DAILY & MONTHLY SNOWFALL (Inches)													
Day Average	0.53	0.33	0.27	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.05	0.27	0.12
Maximum for Month	90.90	58.50	45.00	32.00	8.00	1.00	0.00	0.00	0.00	1.00	14.00	49.50	167.20
Maximum for Year	1950	1969	1967	1982	1950	1967	1990	1990	1990	1948	1955	1971	1952
Minimum for Month	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum for Year	1991	1991	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990

TABLE 2-2
SUMMARY OF CLIMATOLOGICAL DATA
1948 - 1991 AT QUINCY STATION

Station:	**QUINCY**	**Latitude:**	**N39:58:00**	**ID:**	**7195**
County:	**PLUMAS**	**Longitude:**	**W120:57:00**	**Begin Date:**	**7/1948**
State:	**CA**	**Elevation:**	**3410**	**End Date**	**2/1991**

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
Month Average	16.06	9.36	8.55	3.37	0.51	0.03	0.00	0.00	0.00	0.03	1.54	8.25	57.69
DAILY & MONTHLY PRECIPITATION (Inches)													
Day Average	0.25	0.22	0.18	0.10	0.05	0.02	0.01	0.01	0.03	0.09	0.20	0.23	0.11
Maximum for Month	22.77	20.18	17.38	10.65	5.43	3.05	1.89	2.47	5.51	17.05	18.70	25.57	77.53
Maximum for Year	1969	1986	1989	1982	1957	1967	1974	1965	1986	1962	1973	1955	1983
Minimum for Month	0.41	0.22	0.82	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.15
Minimum for Year	1991	1971	1956	1985	1954	1987	1989	1987	1988	1978	1959	1989	1949
Month Average	7.38	6.13	5.50	2.83	1.52	0.71	0.18	0.35	0.86	2.84	5.59	6.97	43.42

3.0 SITE GEOLOGY

A detailed description of the mine site characterization study was presented in a Phase I report submitted to the Regional Board. The following is a summary of geologic information important to the development of a subsidence diversion facility at the Walker Mine.

3.1 GEOLOGY

The Walker Mine is located in the northern portion of the Sierra Nevada physiographic province. The area is composed of deformed and weakly metamorphosed Paleozoic and Mesozoic sedimentary and volcanic rocks which were intruded by Late Mesozoic plutonic rocks of the Sierra Nevada batholith. There are five orebodies aligned in a northwesterly direction. They consist of massive chalcopyrite-pyrite stringers and seams within a northwest striking shear zone that cuts basic schistose and hornfelsic rock near a contact with intrusive quartz diorite. Chalcopyrite is the principal ore mineral, but minor proportions of chalcocite and tetrahedrite are present. Sphalerite, galena, stibnite, and jamesonite occur as accessory minerals (Averill, 1937). The mine produced approximately 5,300,000 tons of ore grading 1.5 percent copper, 0.70 ounce per ton silver, and 0.04 ounce per ton gold and operated from 1915 to 1941 (Prochnau, 1986).

3.2 UNDERGROUND MINE WORKINGS

The Walker Mine property has been extensively developed underground and explored by diamond drill holes. The seventh level adit, about 900 feet below the surface at an elevation of 6,220 feet, was the main haulage level. The first 3,000 feet of this level was driven through diorite until the South orebody (250 feet long) was intersected. The adit then turns northwest and follows the mineralized shear zone intersecting first the Central, then the Northern, 712, and the Piute orebodies for a total portal distance of 10,000 feet. These five high-grade ore zones along this linear zone ranged from 600 to 1,400 feet in length and 30 to 40 feet in thickness. Ore depth below the surface ranges from 400 to 900 feet. Workings extend to the 12th level at a depth of approximately 1,800 feet. There are an estimated 12 miles of underground tunnels with a total potential mine void estimated at 44,118,000 cubic feet or 330 million gallons (Figure 3-1). The extent of underground tunnel cave-in is unknown.

7212
6180
1032

11-7-95

82 psi
2.311
~190 ft
→ 210-220 mgal

2' contour map - copy?

What's the sheet area for sinkholes? Creek?

Water elevation behind the mine seal varies seasonally with the highest levels occurring during spring snowmelt. Water elevation behind the seal is commonly on the order of 40 to 80 feet above the mine seal (180 million gallons). The highest recorded water elevation behind the seal was 110 feet above the portal level (200 million gallons).

3.3 GEOMORPHOLOGY

There are several subsidence features or sinkholes that are found north of the main portal area at the surface along the northwestern tend of the orebodies. These features have been mapped and are shown in Figure 3-2. There are two areas of subsidence; in the Central ore zone (3 sinkholes) and in the Piute ore zone (5 sinkholes). The morphology of the sinkholes most closely resembles a cone-shape and volume estimates were calculated based on this configuration (Table 3-1). The radius and heights were estimated using the 2-foot-contour map generated for the sinkhole areas. Total sinkhole volumes are estimated to be 508,950 cubic feet (18,600 cubic yards). Individual sinkhole volumes range from 4,200 to 179,600 cubic feet.

The catchment pond is approximately 0.97 acre in size and is located in a region of low lying topography south of the mine portal and waste rock piles. The area surrounding the pond is on the order of 4 to 5 acres and gently slopes to the south at a grade of about 2 percent. Water from the pond flows into Dolly Creek when the water elevation exceeds 6,200 feet.

TABLE 3-1
SINKHOLE VOLUME ESTIMATES -
WALKER MINE SITE

	Radius (ft)	Height (ft)	Volume (ft^3)	Volume (yd^3)
Central Sinkholes				
1	55	34	107,700	3,980
2	70	35	179,600	6,640
3	25	15	29,450	1,090
		SUBTOTAL	316,750	11,710
Piute Sinkholes				
1	50	25	65,450	2,420
2	45	27	57,250	2,120
3	40	15	25,100	930
4	40	24	40,200	1,490
5	20	10	4,200	155
		SUBTOTAL	192,200	7,110
		TOTAL VOLUME	**508,950**	**18,820**

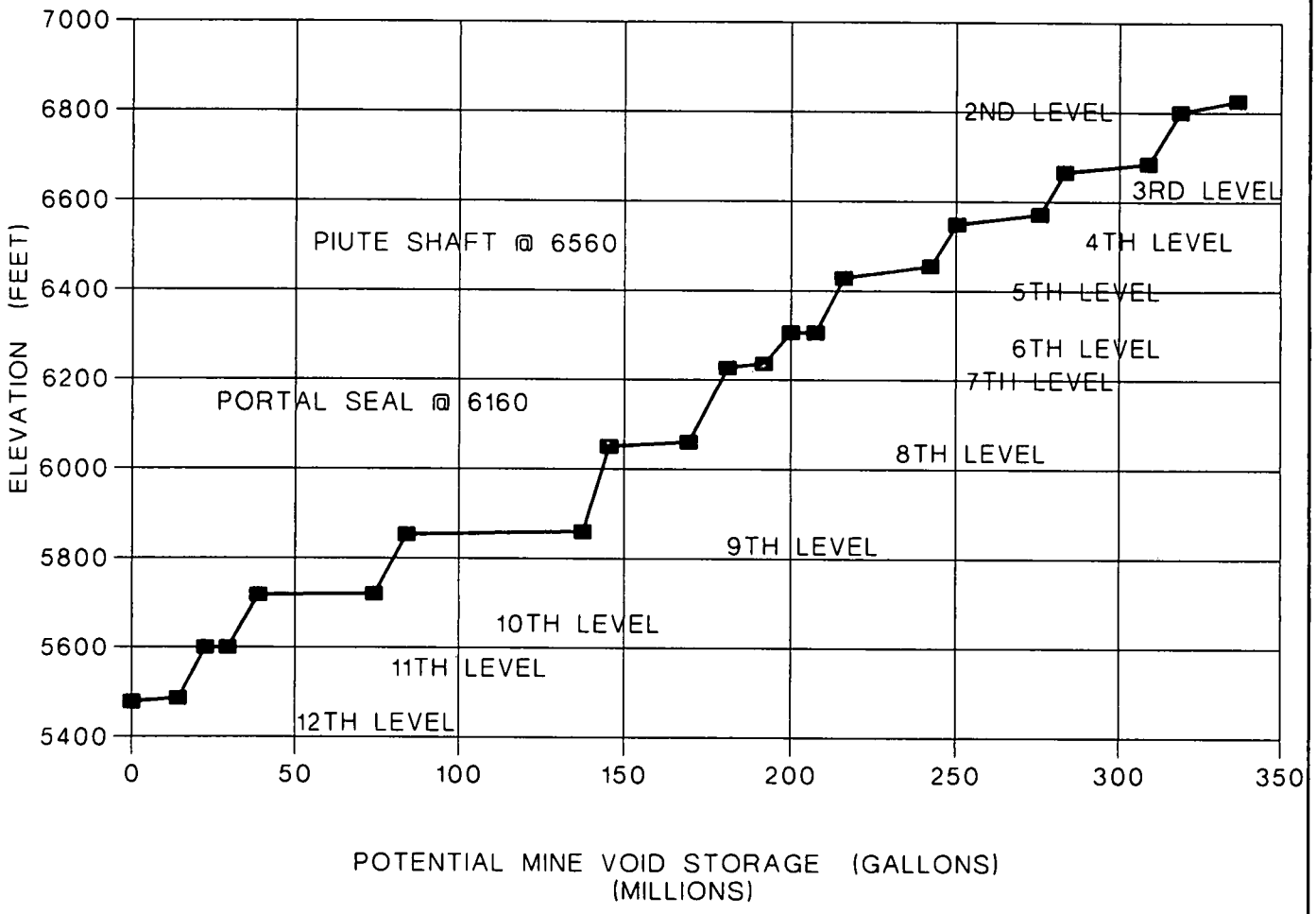

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FIGURE 3-1

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

MINE WATER STORAGE

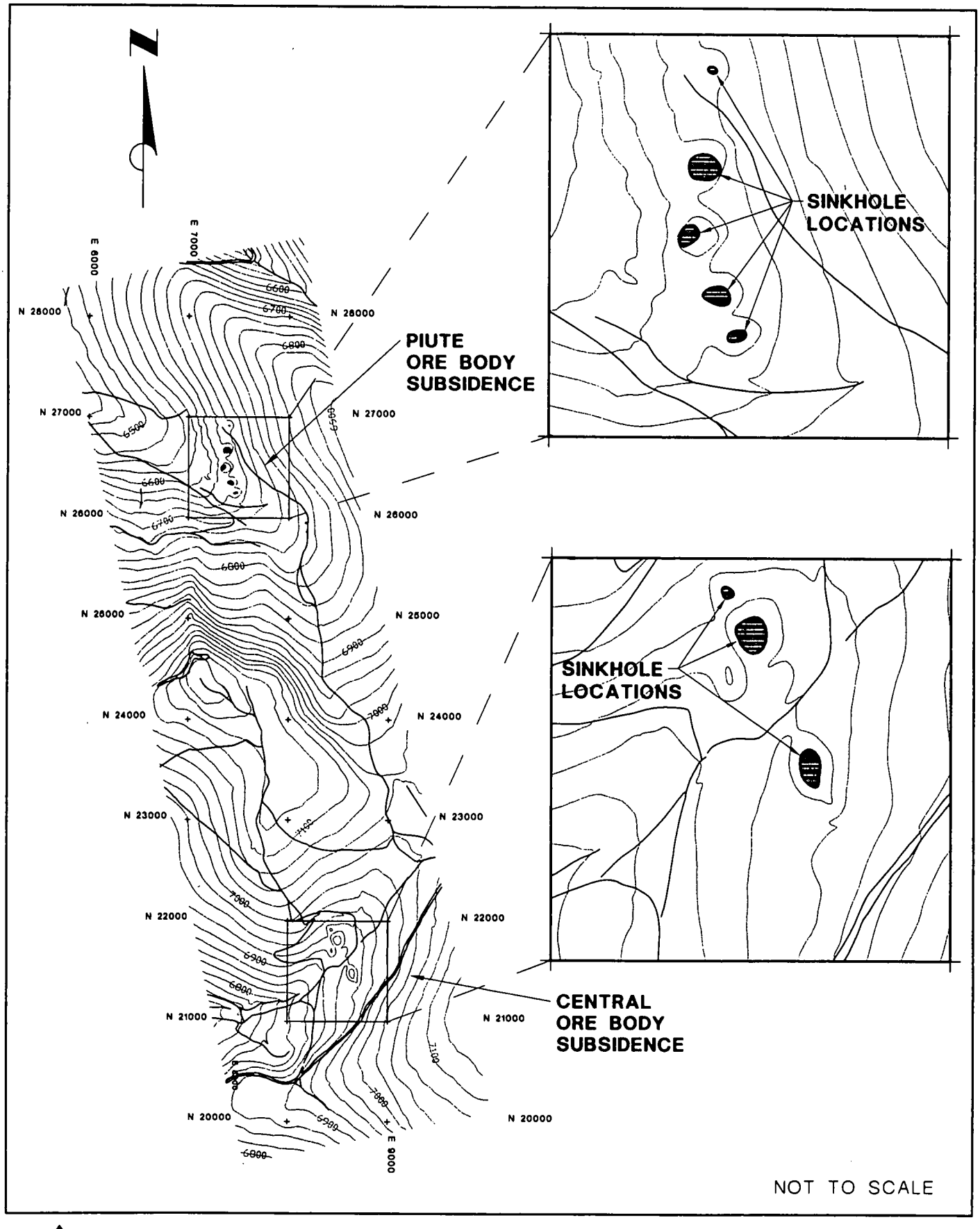

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FIGURE 3-2

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE1

TOPOGRAPHIC MAP OF SINKHOLE AREAS

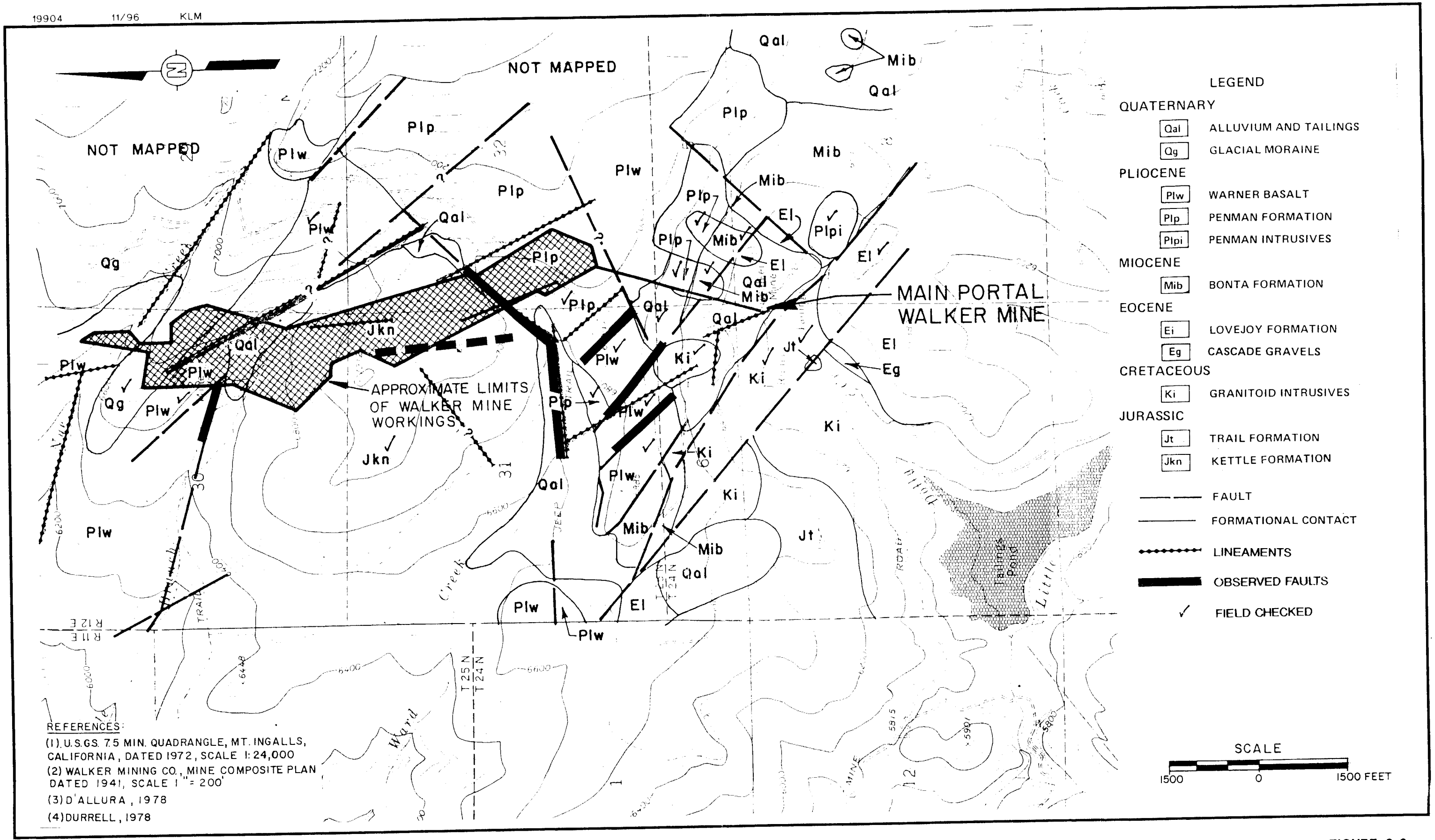
3.4 STRUCTURAL GEOLOGY AND POTENTIAL GROUNDWATER PATHWAYS

Existing geologic information was evaluated and field checked in order to assess the potential for movement of groundwater into the mine via structural zones. In order to characterize the potential for groundwater movement along structures, a limited lineament study of the air photo coverage along the 700 level adit from the portal north to the Piute sinkholes was conducted. Existing geologic maps received from the California Regional Water Quality Control Board were also evaluated. Both the lineament study and the geology maps were field checked to evaluate the validity of observations on each.

A number of lineaments were identified on air photo stereo pairs and are shown on Figure 3-3. Those lineaments having the potential to impact where channel groundwater flows into the mine were field checked to ascertain whether the lineament was associated with a fault or a fracture and whether or not that fracture system was open or closed. Some of the lineaments were confirmed to be faults and have been identified as such on the geology map (Figure 3-3). Other lineaments were not directly associated with any direct evidence of faulting or fracturing in the field and are referred to simply as lineaments on the geology map.

The features identified as faults and lineaments were examined to assess the potential for the feature to either channel or block groundwater from entering the mine. Some of these features were exposed directly in the walls of the collapsed sinkhole areas. These fractures were typically filled with rock flour and had some open spaces up to 1/8 inch in width. However, the open fractures appeared to have been aggravated by the presence of surficial erosion. In general, field evidence was found to be inconclusive; however, there was no direct evidence of major fracture systems that would provide a pathway for groundwater either into or out of the mine workings.

19904 11/96 KLM



REFERENCES:

(1) U.S.G.S. 7.5 MIN. QUADRANGLE, MT. INGALLS, CALIFORNIA, DATED 1972, SCALE 1:24,000

(2) WALKER MINING CO., MINE COMPOSITE PLAN DATED 1941, SCALE 1" = 200'

(3) D'ALLURA, 1978

(4) DURRELL, 1978

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REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

FIGURE 3-3

SITE GEOLOGIC MAP

4.0 WETLANDS

4.1 WETLAND PLANT COMMUNITIES OF THE WALKER MINE

The entire proposed Walker Mine project area (Figure 4-1) was surveyed for wetland/riparian areas. The main wetland areas to be discussed in this report were identified on and adjacent to the Middle Branch of Ward Creek in the northern portion of the project area. Some riparian vegetation also occurs along the lower portion of Nye Creek in the Northeast portion of the project.

4.1.1 Upper Middle Branch Draw

Two main wetland vegetation types were identified within upper Middle Branch draw during the field reconnaissance in the Fall of 1992. A complete listing of wetland plant species encountered is provided in Table 4-1. Color photographs of representative areas are included as Figures 4-2 through 4-5. The first type is the alder thicket (*Alnus incana var. Tenuifolia*) occurring primarily along the active stream channel. The mountain alder is the dominant overstory species with brackenfern (*Pteridium aquilinum*), Nebraska sedge (*Carex nebrascensis*), and groundsel (*Senecio serra*) as dominant understory species. In occasional areas along the stream channel, Lemon willow (*Salix lemmonii*) is present with similar understory.

The second wetland vegetation type identified in this area is the dry meadow type dominated on the meadow edges by Lodgepole pine (*Pinus contorta*). The main portion of the meadow is dominated by graminoid and herbaceous species such as cinquefoil (*Potentilla gracilis*), sub-alpine needlegrass (*Stipa columbiana*), blue wildrye (*Elymus glaucus*), and longleaf clover (*Trifolium longipes*). In the moister areas of the meadow such species as swordleaf rush (*Juncus ensifolius*), straight leaf rush (*Juncus orthophyllus*), and alpine timothy (*Phleum alpinum*), dominate the community.

In the Upper portion of Middle Branch draw, an old cabin was noted in the wooded upland area bordering the meadow type. The upland area is dominated by red and white fir (*Abies magnifica* and *concolor)*, Jeffrey pine (*Pinus jeffreyi*), greenleaf manzanita (*Arctostaphylos*

patula), and bittercherry (*Prunus emarginata*). There are still several old growth red fir in and around the cabin area.

4.1.2 Lower Middle Branch Draw

Three main wetland vegetation types were identified along the lower portion of Middle Branch draw, wet meadow, dry meadow, and alder thicket. The wet meadow type is located above the intersection of the road and the creek, and can be described topographically as a hanging valley. This area is saturated by groundwater for a major portion of the year and has a high build-up of organic matter in the upper portions of the soil profile. This area is dominated by primrose monkeyflower (*Mimulus primuloides*), groundsel (*Senecio serra*), false hellebore (*Veratrum californicum*), Nebraska sedge (*Carex nebrascensis*), western ledum (*Ledum glandulosa*), and cliff sedge (*Carex scopulorum*).

The dry meadow type is located below the wet meadow type near the intersection of the road and the creek. This type is dominated by sage (*Artemisia ludoviciana*), blue wildrye (*Elymus glaucus*), redtop (*Agrostis stolonifera*), goldenrod (*Solidago canadensis*), and monkeyflower (*Mimulus guttatus*). Areas adjacent to the creek are dominated by Pacific tree willow (*Salix lasiandra*) and Mountain alder (*Alnus incana* var. *Tenuifolia*).

The last type identified in the lower Middle Branch draw is the alder thicket (*Alnus incana* var. *Tenuifolia*). This type is similar in species and structure to the alder thicket described for the upper Middle Branch draw. Alder is the dominant species with two or three under species.

4.1.3 Nye Creek Drainage

The Nye Creek drainage is present in only a small portion of the proposed project near the northeast corner. This drainage is very narrow and steep and is dominated primarily by willow and alder. The main willow species are Pacific tree willow (*Salix lasiandra*) and lemon willow (*Salix lemmonii*). The alder is mountain alder (*Alnus incana* var. *tenuifolia*).

4.2 CONCLUSION

Wetland and riparian plant communities do exist in the proposed Walker Mine project area. At this time only a reconnaissance level survey of the communities was performed; a formal wetland delineation was not conducted.

INSERT FIGURE 4-1

TABLE 4-1
WALKER MINE WETLAND PLANT SPECIES LIST

GENUS/SPECIES	COMMON NAME
Abies concolor	White fir
Abies magnifica	Red fir
Achillea millefolium	Yarrow
Agrostis idahoensis	Idaho redtop
Agrostis stolonifera	Redtop
Agropyron trachycaulum	Slender wheatgrass
Alnus incana var. Tenuifolia	Mt. alder
Amelanchier alnifolia	Serviceberry
Artemisia ludoviciana	Sagebrush
Arctostaphylos patula	Greenleaf manzanita
Aster foliaceous	Alpine leafbract aster
Bromus carinatus	Mountain brome
Carex nebrascensis	Nebraska sedge
Carex scopulorum	Cliff sedge
Ceanothus cordulatus	Whitethorne
Elymus glaucus	Blue wildrye
Epilobium sp.	Willoweed
Gayophytum sp.	Groundsmoke
Geum macrophyllum	Large leaf avens
Hieracium albiflorum	White hawkweed
Juncus	Swordleaf rush
Juncus nevadensis	Nevada rush
Juncus orthophyllus	Straight leaf rush
Ledum glandulosum	Western ledum
Mimulus guttatus	Monkeyflower
Mimulus primuloides	Primrose monkeyflower
Penstemon rydbergii	Whorled penstemon
Phleum alpinum	Alpine timothy

TABLE 4-1 (continued)
WALKER MINE WETLAND PLANT SPECIES LIST

GENUS/SPECIES	COMMON NAME
Pinus contorta	Lodgepole pine
Pinus jeffreyi	Jeffrey pine
Pinus monticola	Western white pine
Potentilla glandulosa	Cinquefoil
Prunus emarginata	Bitter cherry
Pteridium aquilinum	Bracken fern
Ribes cereum	Wax currant
Ribes montigenum	Gooseberry currant
Rubus parviflorus	Thimbleberry
Salix lasiandra	Pacific tree willow
Salix lemmonii	Lemon willow
Senecio serra	Groundsel
Senecio triangularis	Arrowleaf groundsel
Solidago canadensis	Canada goldenrod
Stachys sp.	Stachys
Stipa columbiana	Sub-alpine needlegrass
Symphoricarpos oreophilus	Snowberry
Trifolium longipes	Long-leaf clover
Veratrum californicum	False hellebore

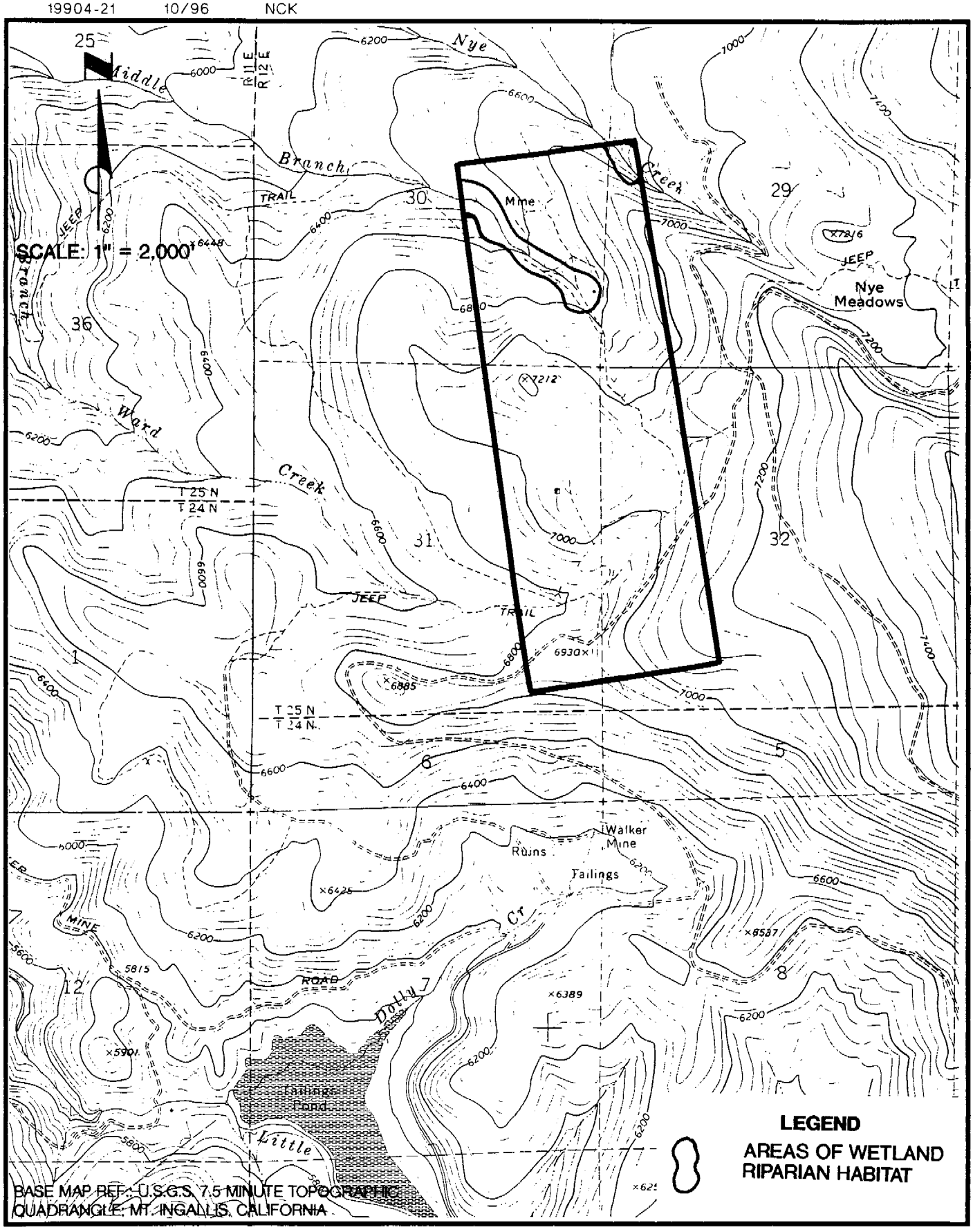

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FIGURE 4-1

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

WETLAND/RIPARIAN SURVEY AREA

DRY MEADOW TYPE

DRY MEADOW TYPE

UPPER MIDDLE BRANCH DRAW

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FIGURE 4-2

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

WETLAND/RIPARIAN
SURVEY PHOTOGRAPHS

UPPER MIDDLE
BRANCH DRAW

CABIN

OLD GROWTH JEFFREY PINE

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FIGURE 4-3

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

WETLAND/RIPARIAN
SURVEY PHOTOGRAPHS

WET MEADOW TYPE

WET MEADOW TYPE WITH ORGANIC MATTER

LOWER MIDDLE BRANCH DRAW

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FIGURE 4-4

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

WETLAND/RIPARIAN
SURVEY PHOTOGRAPHS

WET MEADOW TYPE

ALDER THICKET

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FIGURE 4-5

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

WETLAND/RIPARIAN
SURVEY PHOTOGRAPHS

5.0 SUBSIDENCE EVALUATION

Subsidence features have been observed above two sections of the Walker Mine, including the Sawmill area and the Piute area (see Figure 5-1).

There are two different types of subsidence profiles commonly observed over mine facilities. They include trough subsidence and chimney subsidence. Trough subsidence is illustrated in Figure 5-2. It is associated primarily with the mining of thin tabular ore bodies such as coal. It produces a broad trough wider than the mine opening itself, with the deepest part of the trough centered over the mine opening. The ground surface within the limits of the subsidence trough may contain some cracking and fissuring, typically not displaying concentrated zones of collapse.

The second type of subsidence feature consists of chimney subsidence. Chimney subsidence is illustrated in Figure 5-3. In the case of chimney subsidence features, the caving zone propagates vertically until it intercepts the surface, forming a well defined sinkhole, sometimes centered within another zone of limited trough subsidence. Although chimney subsidence can occur above any mine opening at shallow depth, it is often associated with shallow stoping methods in metal mines which can produce voids of sufficient extent that the caving zone can propagate to great distances above the mine, before either an arch can form or the volume is filled with a bulk rubblized mass. The subsidence features observed above the Walker Mine are consistent with the chimney subsidence type of mechanism.

In addition to showing the location of observed subsidence features on-site, Figure 5-1 also shows estimated limits of fracturing (i.e., trough subsidence zones) on either side of the observed subsidence craters. Areas outside of these limits should be reasonably safe from future subsidence activity; however, areas within these zones might still be subject to additional subsidence effects in the future, particularly where the thickness of cover above mine openings is small. As lined diversion options are implemented resulting in some degree of dewatering of the mine workings, subsidence effects could be increased due to a reduction in hydrostatic pressure within the workings; however, there is some reason for optimism since the majority of the subsidence features that have propagated to the surface are associated

with the higher levels of the mine which are currently dry and should remain dry. Nevertheless, maintenance provisions for installed diversion systems should include routine inspection for evidence of additional subsidence which could alter grades, reduce freeboard, and potentially breech diversion channels. Inspection for changes in line and grade should become a routine portion of future maintenance.

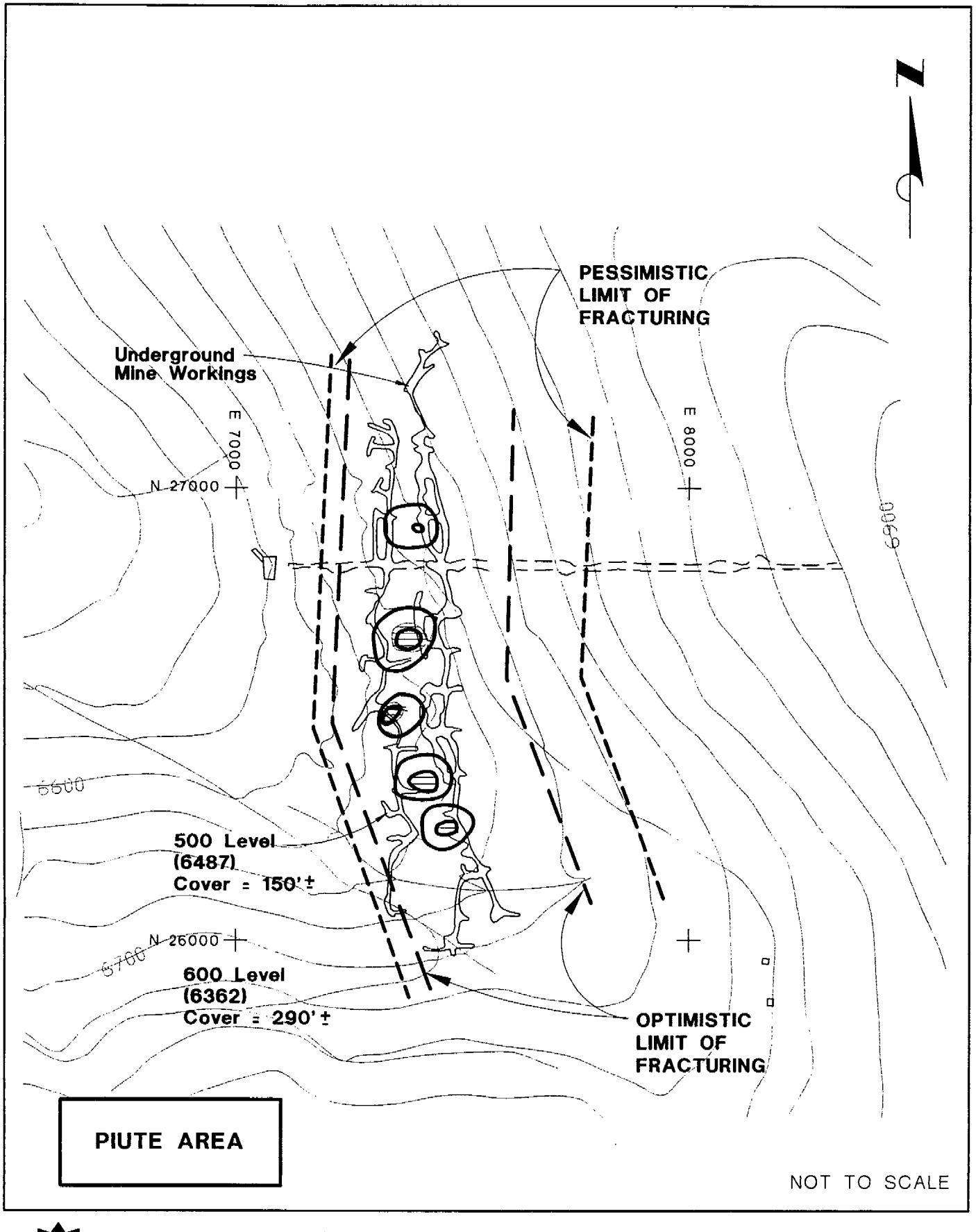

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FIGURE 5-1A

ESTIMATED LIMITS OF FRACTURES

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WALKER MINE
W3E PHASE 1

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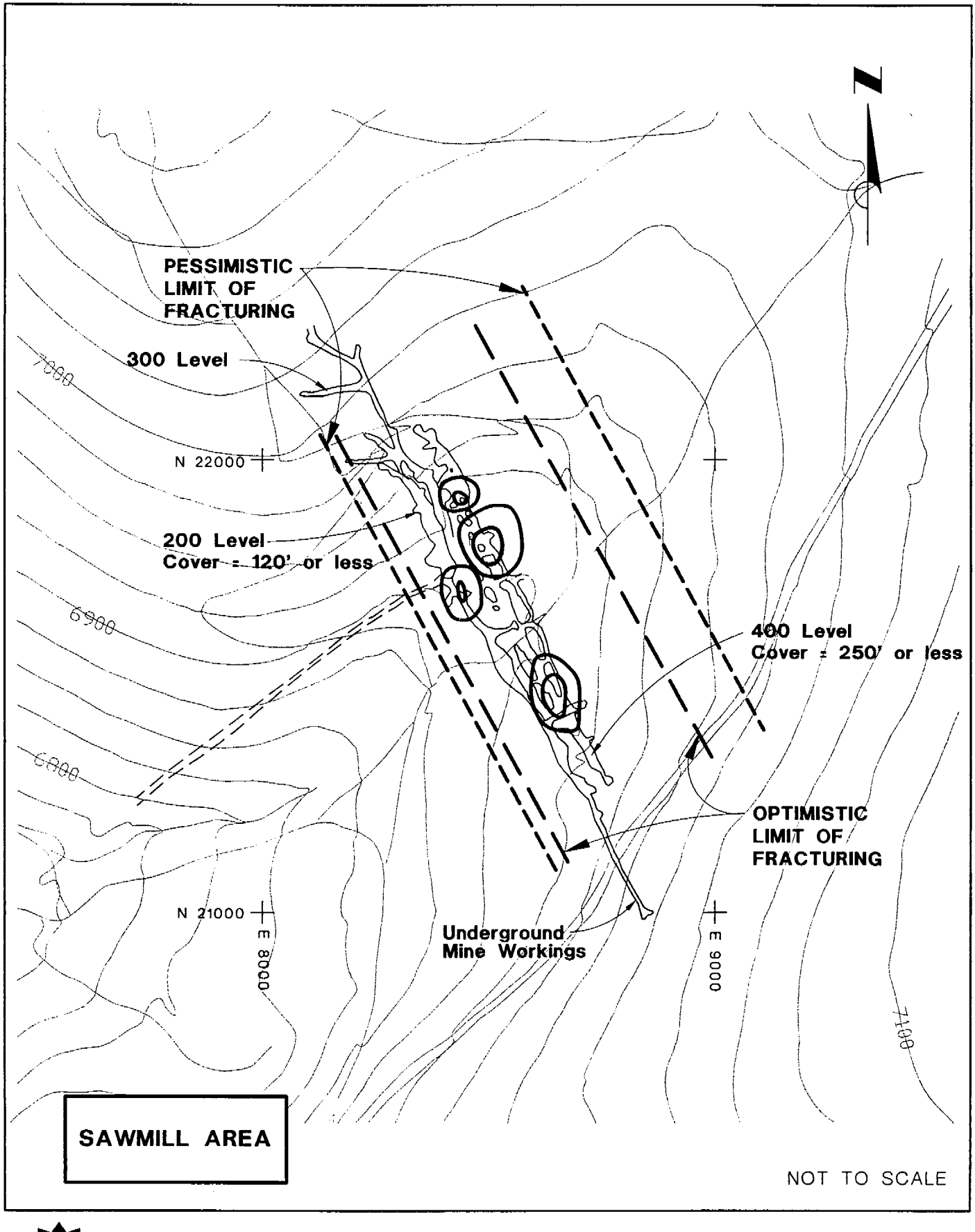

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FIGURE 5-1B

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

ESTIMATED LIMITS OF FRACTURES

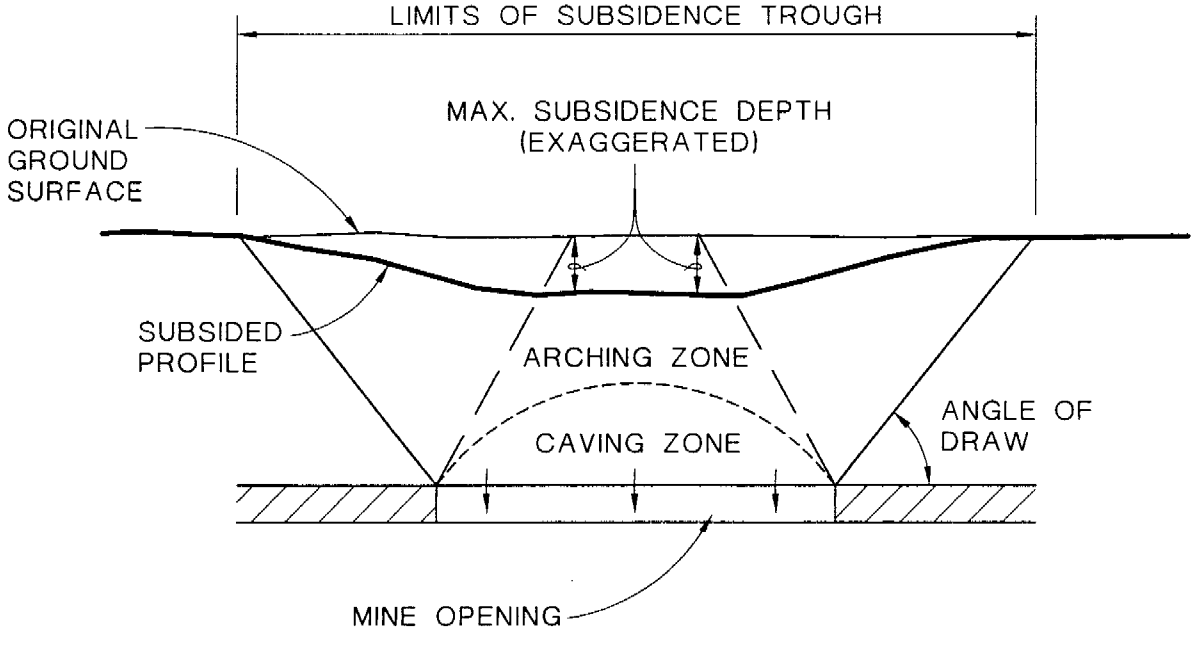

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FIGURE 5-2

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

TROUGH SUBSIDENCE OVER MODERATE TO DEEP MINE OPENINGS OF LIMITED THICKNESS

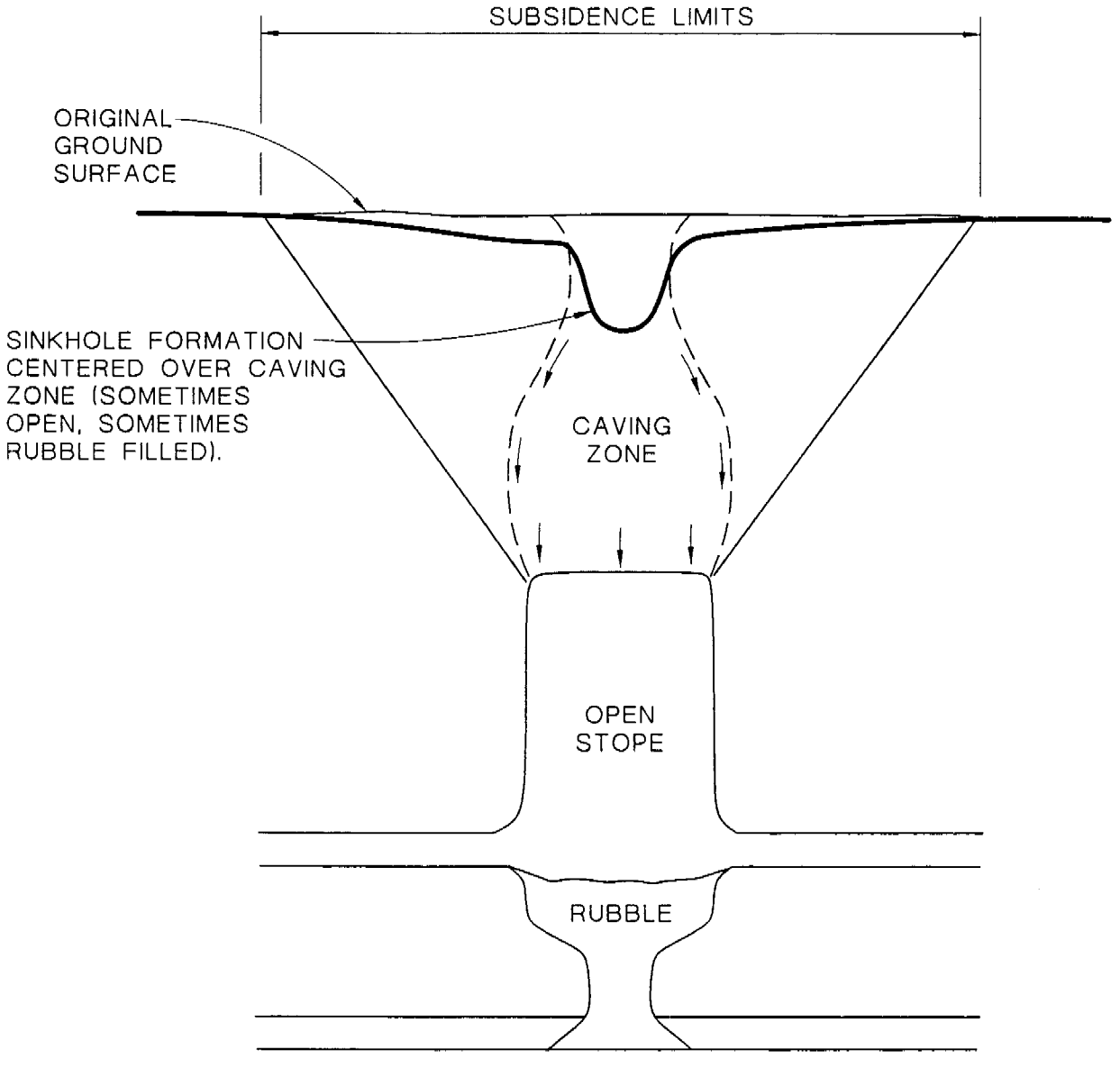

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FIGURE 5-3

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
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CHIMNEY SUBSIDENCE OVER A SHALLOW OPEN STOPE

6.0 HYDROLOGIC EVALUATION

6.1 BASIN CHARACTERISTICS

In order to estimate runoff characteristics for the sinkhole areas, the USGS 7.5 minute topographic map was used to determine the extent of each basin that would contribute to each sinkhole area. The Central basin was found to encompass an area of 0.53 square miles and the Piute basin was found to encompass an area of 0.42 square miles. The extent of each basin are shown graphically on Figure 6-1. Each basin slopes to the southwest at relatively consistent grades. The majority of each basin is covered with surface soils less than 3 feet thick. The areas directly up hill from each sinkhole site contain surficial alluvial soils that range from 5 to 10 feet in thickness. Considering the elevation of the areas (6,600 to 7,000 feet), runoff could come in the form of rainfall and/or snowmelt. Given this situation, both possibilities were modeled.

6.2 RAINFALL

A computer-assisted hydrological model, "TR-20," developed by the Soil Conservation Service (SCS), was used to estimate the ensuing runoff peak discharge that could occur within the limits of the project area from a synthetic storm as the result of the assumed 24-hour rain storm event. The following were used to define the data needed as input in the computer model.

1. An SCS curve number of 66 and antecedent moisture condition II were assigned to the basins to partition the runoff and infiltration components of design rainstorm events in each of the basins.

2. The time of concentration for the basin was estimated using the procedures outlined by the SCS in "TR-55, Hydrology for Small Watersheds."

3. The storm event associated with a 100-year, 24-hour recurrence interval was used as the design storm for the sizing of diversion facilities.

4. The standard SCS 24-hour Type II cumulative rainfall distribution was used to generate synthetic storm data.

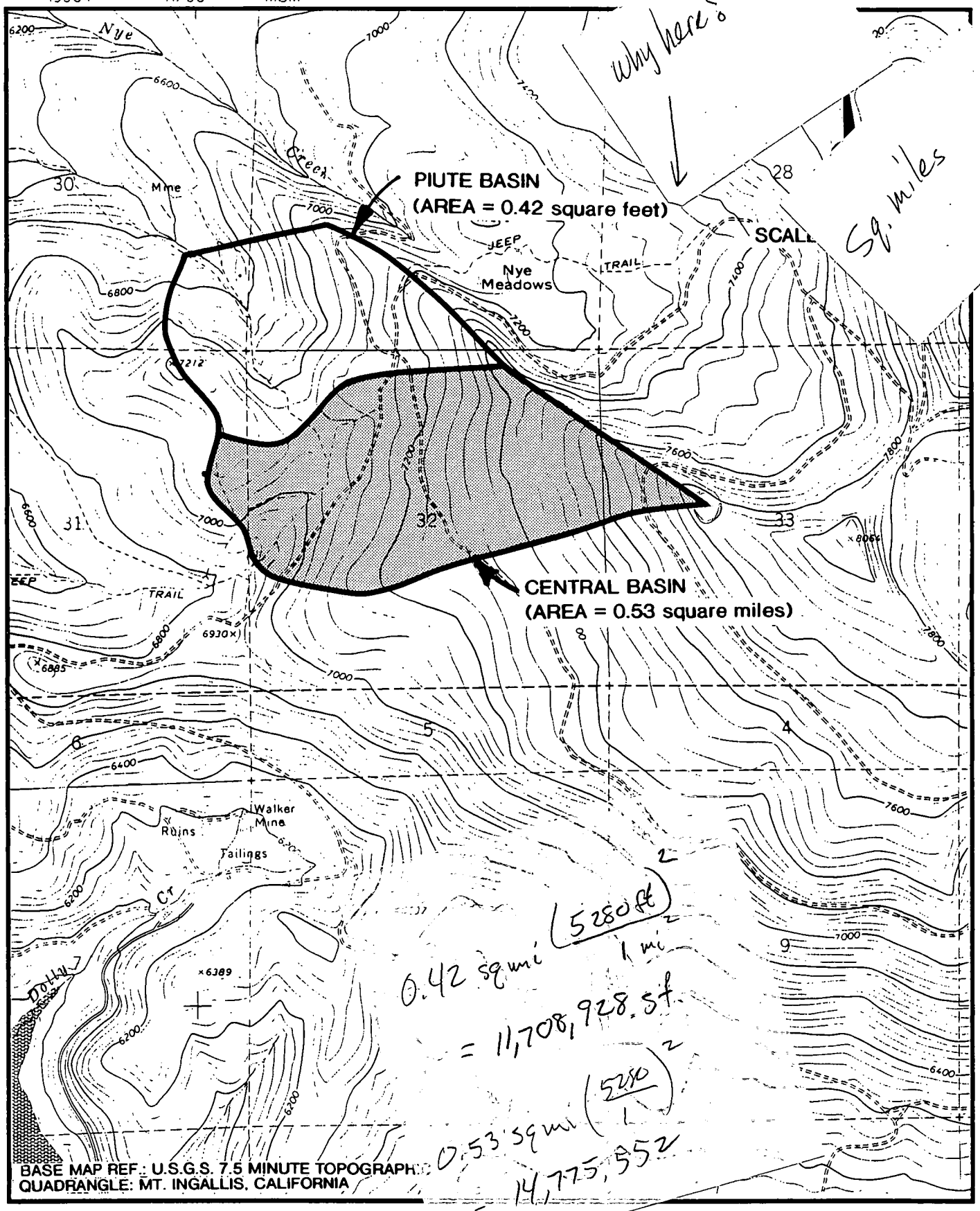

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FIGURE 6-1

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

HYDROLOGIC BASIN AREAS

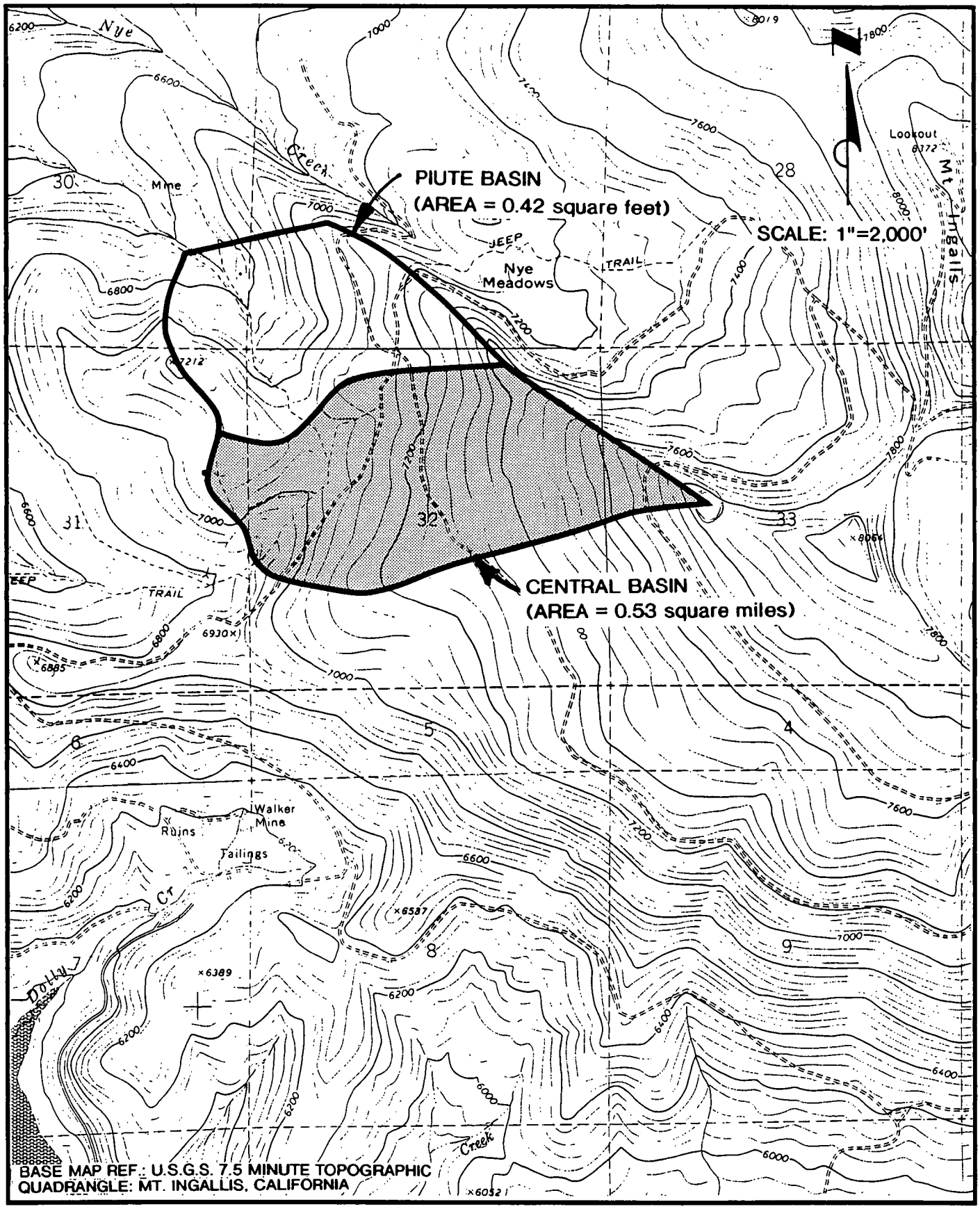

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FIGURE 6-1

REGIONAL WATER QUALITY CONTROL BOARD
WALKER MINE
W3E PHASE 1

HYDROLOGIC BASIN AREAS

100yr-24hr Storm Snow

Central 686 cfs 3.4

Piute 668 cfs 2.7

Snowmelt-

~~3.4 cfs~~

Results of computer modeling indicated that the Central subsidence area could experience a peak runoff of approximately 686 cubic feet per second (cfs) and the Piute subsidence area could experience peak runoff of approximately 668 cfs.

6.3 SNOWMELT

Given the location and altitude of the site, it is the opinion of WESTEC that the runoff volume produced by snowmelt is greater and has a much greater impact on the annual volume of water contributed to the existing underground workings than the runoff volume associated with precipitation in the form of rainfall. This opinion is further supported by existing data on the monitoring of water levels within the mine workings and was discussed in more detail in Section 3.2.

Runoff from snowmelt was modeled using procedures outlined in the U.S. Army Corps (Corps) "Runoff from Snowmelt" EM 110-2-1406. This manual details procedures for estimating snowmelt caused by spring thaw and snowmelt caused by rain on snow. Inputs needed for the runoff from snowmelt caused by spring thaw model include:

1. **Daily average temperature data:** Daily minimum and maximum temperature data for the 44 years of record were retrieved for the Portola, California recording station using CD-ROM software entitled "NCDC Summary of the Day" by Earthinfo, Inc. The average daily temperature was calculated as the arithmetic average of the two. The temperature data were adjusted for the difference in elevation between Portola and the project site, between 2,000 and 3,000 feet, using relationships outlined in "Runoff from Snowmelt."

2. **Estimation of the length of snowmelt season:** Analysis of snow-course data provided by the California Cooperative Snow Surveys for the Grizzly #359 site, located immediately south of the project site, indicated the snowmelt season is on average about two months in duration, lasting from approximately May 1st through the end of June for each year.

3. **Estimation of the snow areal coverage versus time relationship for the snowmelt season:** This is affected by the orientation of the drainage basin, which in the case of the Walker Mine subsidence areas faces predominantly to the southwest. A basin having the same type of orientation throughout leads to a snow areal coverage versus time relationship that is estimated to be linear. In other words, the areal extent of the snow will be reduced the same amount each day once melting has started. This relationship becomes most important when estimating the volume of water available for runoff.

4. **Estimation of snowmelt lost to infiltration:** Based on information provided by the "Runoff from Snowmelt" manual, 0.3 inches per day snowmelt is estimated to be lost to infiltration.

Analysis of runoff from snowmelt caused by spring thaw indicates that the base flow from snowmelt would peak at approximately 3.4 cfs for the Central subsidence area and 2.7 cfs for the Piute subsidence area.

As previously stated, estimation of runoff was also analyzed for rain on snow conditions. In addition to the four items outlined above, the daily precipitation data for the area is required. These data were retrieved for the Portola, California recording station using CD-ROM software entitled "NCDC Summary of the Day" by Earthinfo, Inc.

To determine the climatic conditions that would result in a one percent exceedence probability for snowmelt (the equivalent of a 100-year recurrence interval event for snowmelt), synthetic probability distributions were modeled on a daily basis for both the daily average temperature data and the daily precipitation data using the 44 years of record as a database. This allowed the exceedence probabilities to be estimated on a daily basis for both daily average temperature and daily precipitation. The rain on snow event is a conditional probability event which requires that the daily average temperature be high enough to induce melting in an existing snowpack and that precipitation occurs concurrently in the form of rain. The final one percent probability of the "rain on snow" event is the product of the exceedence probabilities of each discrete event—a temperature high enough to produce melt and the occurrence of precipitation in the form of rain—both at a ten percent exceedence level. The combination of these data when used in the Corps generalized snowmelt model for rain on snow equation results in the amount of snowmelt that would occur at a one percent exceedence probability for each day (i.e., the conditional probability of the combined events would become 0.1 X 0.1 or 0.01). This model was used for days when the daily average temperature at the project site was above 35°F. This temperature is the breakpoint between a rain or snow event. Temperatures below 35°F are assumed to result in snowfall.

In addition to the runoff caused by melt during a rain on snow event is the runoff caused by the rain event itself. This runoff was estimated using the "TR-20" program in a manner similar to that stated above, with the following difference:

1. An SCS curve number of 99 and antecedent moisture condition III were assigned to the basin to quantify the amount of runoff losses. These values were used to ensure that the model not allow infiltration from the rain event since the infiltration capacity of the soil was fully satisfied by the snowmelt.

2. The storm event associated with the same ten percent exceedence probability used to induce snowmelt was utilized to estimate rainfall runoff volume.

Analysis was undertaken to determine the critical combination of runoff from snowmelt and runoff from rainfall. Peak discharge was found to be controlled by the magnitude of the rain event which is estimated to be 80 cfs for the Central subsidence area and 77 cfs for the Piute subsidence area. These discharges are composed of approximately 3 cfs of base flow from snowmelt with the balance being discharge from the rainfall runoff in each case.

Given the results of the above described analysis, it is apparent that the peak discharge rate associated with a one percent probability rain on snow event does not exceed the estimated peak discharge from the one percent probability rainfall event and therefore will not control the sizing of diversions. Of greater interest is the volume of water available in the snowpack for melting and discharging into the mine, via the sinkholes. This melt water can enter the mine in two ways; by direct surface runoff into the sinkholes and by lateral migration through the surficial soils that are adjacent to each sinkhole area. Each of these possibilities has been modeled and is described in detail below.

6.4 MODELING OF SNOWMELT DISTRIBUTION

In order to estimate the amount of snowmelt water that may enter the mine through the subsidence zones, a model was derived to separate the melt water into its component parts including losses to the local groundwater table (i.e., water that does not enter the mine), flow into mine through soils adjacent to the subsidence zones, and surface flow. The model is based on snowmelt calculations using the Corps generalized snowmelt model described above. This model is affected the most by the physical characteristics of the basin. This includes the type and thickness of soils within the basin, presence of a fractured bedrock layer capable of transmitting significant volumes of water away from the surface to the general water table depth, the average slope of the basin, and the presence of any alluvial stream beds or diversion channels capable of directing flows within the basin.

6.4.1 Physical Characterization of Basins

As stated previously, basin characteristics typical of areas around the subsidence zones include the presence of shallow surficial soils. Over the majority of each basin, the depth of soil is estimated to be less than three feet. Given this condition, these areas are assumed to be influenced more by fractured bedrock lying directly below the surface than by the thin soil

veneer. Therefore, these areas will behave in a manner consistent with bedrock and not soil. In other words, the fate of infiltration water will be controlled by the fractured rock, and the soil is assumed not to transport water over significant lateral distances. Exceptions to this type of behavior occur in areas that contain permeable alluvial soils with depths in excess of five feet.

Such areas occur in the valley floors directly upgradient of each subsidence zone. These areas contain soil layers that are typically five to ten feet in thickness, respectively, for the Central and Piute subsidence zones. In these areas, melt water can enter and flow laterally through the soil until it daylights in the subsidence craters and flows directly into the mine.

Melt water that flows through the alluvial soil layers is assumed to move in accordance with the following scenario:

1. Melt water enters the alluvial soil and creates a wetting front that migrates vertically downward through the thickness of the alluvial soil layer until contacting the interface with the fractured rock below.

2. Once contact with the fractured rock has been made, any excess water (i.e., what does not infiltrate into the rock) will saturate the soil above the fractured rock interface.

3. Once the alluvial soil is saturated, water will begin to migrate laterally toward the mine workings.

Infiltration and vertical seepage rates have been estimated using the procedure of McWhorter and Nelson (Journal of Geotechnical Engineering, Vol. 105, No. GT11, November 1979. American Society of Civil Engineers). Lateral flow into the mine is assumed to follow Darcy's law ($Q = kiA$). In this model we have chosen a permeability of 1×10^{-3} centimeters per second (cm/s) for the soil based on field data of surface infiltration testing conducted around the subsidence zones. The volume of water estimated to be transported laterally toward the mine in this manner is quite small. For the Piute subsidence area this flow is the equivalent of 0.01 inches of daily melt water. For the Central subsidence area it is estimated to be the equivalent 0.006 inches of daily melt water through the soil.

A significant amount of melt water is lost through infiltration into fractured rock. For the purposes of this model the fractured rock is assumed to have a bulk permeability of approximately 1×10^{-5} cm/s, or an equivalent infiltration rate of 0.30 inches per day. This

Local GW table.

water is considered to be lost to the local groundwater table and is not available to fill the mine workings. Any melt water that is in excess of the volume loss to the local groundwater and the lateral flow through the alluvial soil is assumed to produce surface runoff.

Surface runoff is assumed to have three potential pathways that it can follow: (1) it can be diverted away from the subsidence craters through the existing surface channels; (2) it can run directly into the subsidence craters; or (3) it can flow naturally past the subsidence craters. A portion of the water diverted by the existing unlined channels can infiltrate through the base of the channels and flow laterally into the adjacent subsidence craters and subsequently into the mine workings.

6.4.2 Probabilistic Modeling of Snowmelt

In order to characterize the variation in water level in the mine workings from year to year, the snowmelt model described earlier was modified to yield synthetic daily snowmelt probability distribution. The model took into account synthetic temperature and precipitation distributions based on actual daily temperature and precipitation data described in previous sections. This complete daily representation of the range of snowmelt possible allowed for characterization of the probable volume of snowmelt for any climatological condition. This relationship is shown graphically in Figure 6-2. The white line at the center of the black band represents the mean or average daily runoff from snowmelt. The outer edges of the black band represent values at plus or minus one standard deviation of the mean value (i.e., 33 percent and 66 percent exceedence, respectively). The thin lines beyond the dark band represent the 5 percent and 95 percent exceedence probabilities for runoff from snowmelt. These exceedence probability levels were used to establish quantitative estimates of runoff for snowmelt for the following conditions:

5 percent	to represent a very wet year (only five percent of the time will snowmelt exceed this amount)
33 percent	to represent a moderately wet year (thirty-three percent of the time the melt will exceed this value)
50 percent	to represent the typical conditions (fifty percent of the time the melt will exceed this amount)
66 percent	to represent a moderately dry year (sixty-six percent of the time the melt will exceed this amount)
95 percent	to represent a very dry year (ninety-five percent of the time the melt will exceed this amount)

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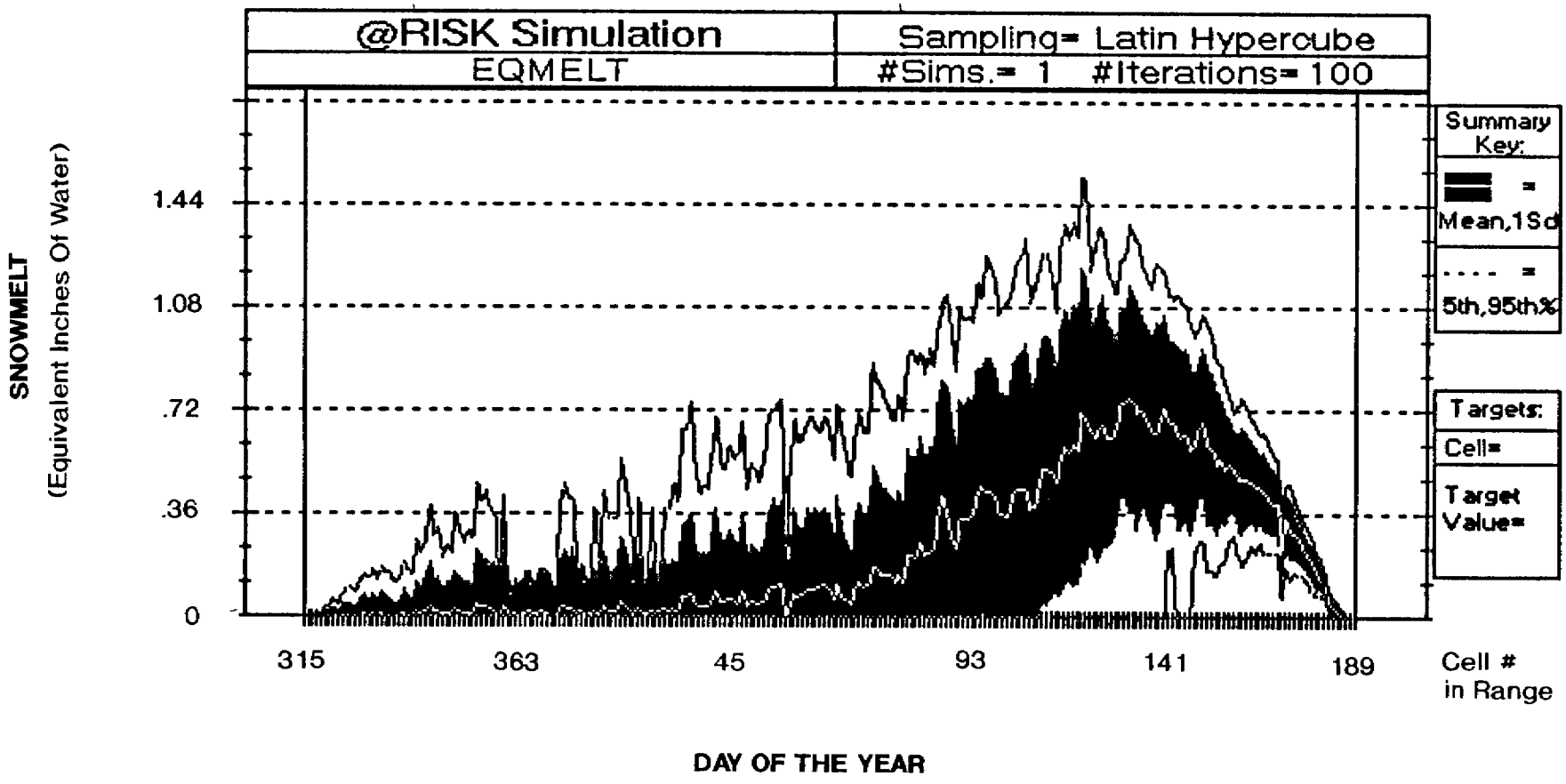

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W3E PHASE 1

FIGURE 6-2

PROBABILISTIC SNOWMELT
VERSUS
DAY OF THE YEAR

6.5 AVAILABLE STORAGE WITHIN THE MINE

The approximate volume of the mine workings was estimated by a number of methods. Records available from the California Division of Mines and Geology indicated that the ore mined between 1916 and 1941 consisted of 5,319,249 short tons. Assuming a mean specific gravity for the material of 2.7, this equates to a volume of 59,897,911 cubic feet or 448,067,490 gallons.

Using available tabulated and scaled information from the composite Walker Mine maps, the following volumes were obtained:

1. The volume of all mapped mined orebodies totaled 257,206,000 gallons;
2. The volume of the mapped ore chutes totaled 5,055,750 gallons;
3. The seventh level adit totaled 4,022,656 gallons;

for a grand total of 266,284,406 gallons.

It is common for production records to be somewhat overstated (for the benefit of potential investors or other reasons). Similarly, it is common for mine maps to lag behind production and never quite catch up with and report all mine tonnage. Therefore, the two distinct estimates should bound real volume of the mine workings. If the higher estimate obtained from production records is reduced to 75 percent of the stated value, the estimate obtained is 336,050,618 gallons. If the volume calculated from available mine maps is similarly increased by 25 percent, the estimate becomes 332,855,508 gallons. Therefore, we have recommended using an estimated approximate mine water storage value of 335 million gallons. The tunnel adit itself, in front of the portal seal, accounts for approximately 5 million gallons. Therefore, the final estimated maximum water storage volume within mine workings has been set at 330 million gallons.

6.6 MODELING OF WATER BALANCE AND PREDICTION OF WATER LEVELS

Given the above described contribution from run-off and infiltration along with the available storage volume estimated from the mine workings at various levels within the mine, a water balance analysis was performed in order to examine potential water level fluctuations within the mine workings associated with the various alternatives. All water balance analyses examined water level fluctuations over a single snowmelt season. All water balance analyses arbitrarily assumed that the initial water level within the mine workings was at 6,262 feet on April 1st and tracked changes in the water level over one full water year ending on March

Start 6262'
Spill 6560
~~298'~~ ~~29~~
~~307~~
298'

11/18/96
77 psi
= 178 ft

6180
178
6357

31st of the following year. Water balance models were prepared for the hypothetical condition of no diversion, for the existing condition of an unlined diversion, for clay-lined diversions, and for plastic-lined diversions. For each of these four distinct alternatives, a water balance model was prepared for exceedence probability levels of 95 percent, 66 percent, 50 percent, 33 percent, and 5 percent. The estimated maximum water surface elevation achieved during a single snowmelt/precipitation season has been summarized for each alternative in Table 6-1. The maximum water surface elevation reported from this modeling effort is 6,560 feet which represents the assumed discharge elevation of the Piute shaft at the ground surface. Detailed summaries of water balance analysis results will be found in Appendix A.

TABLE 6-1
MAXIMUM WATER SURFACE ELEVATION

	WATER SURFACE ELEVATIONS				
Alternative	5 percent Exceedence	33 percent Exceedence	50 percent Exceedence	66 percent Exceedence	95 percent Exceedence
No Diversions	Spill @ 6,560*	Spill @ 6,560*	Spill @ 6,560*	Spill @ 6,560*	6,262
Unlined Diversions	Spill @ 6,569*	6,555	6,454	6,377	6,262
Clay Lined Diversions	6,265	6,262	6,262	6,262	6,262
Geosynthetic Lined Diversions	6,265	6,262	6,262	6,262	6,262

* If the water surface elevation reaches elevation 6,560, water will spill from the Piute Shaft.

Ditches	Now	New	Proposed
Central	1450	£1000	
Pinto	750		
		where?	
	420,000		

7.0 SURFACE AND SUBSURFACE DIVERSION ALTERNATIVES

Given the volume of water available to enter the mine via the sinkholes on an annual basis, it was realized many years ago that some level of effort must be made to divert as much of this water as reasonably possible around the sinkholes and convey it downhill. Some effort has already been made to accomplish this. At present, approximately 2,200 lineal feet of diversion channel exist within the area of the sinkhole craters. As shown in Figure 7-1 this is comprised of 750 lineal feet of channel at the Piute area and 1,450 lineal feet at the Central site. These diversions intercept and redirect approximately 83 percent and 100 percent of the surface runoff for the Piute and Central basins, respectively. This equates to approximately 91 percent of all surface runoff of concern being intercepted. However, as these diversions are in close proximity to the sinkholes and are at present unlined, there are losses of water to the subsurface from the floor of the diversions that migrate toward the subsidence craters and into the mine workings. These losses reduce the net amount of water successfully diverted to approximately 77 percent for mean runoff conditions.

This current situation has many possibilities for improvement. In fact it would be possible to implement a combination of synthetically lined surface diversions and subsurface intercept drains that would practically eliminate any runoff from entering the mine. WESTEC has analyzed four alternatives aimed at significantly reducing the entrance of water into the mine. These alternatives are discussed in detail in the following sections.

7.1 PRE-DIVERSION BASELINE CONDITIONS

Prior to the development of the existing subsidence features, surface run-off was concentrated in moderately entrenched drainage channels flowing on predominantly medium- to coarse-grained silty sand soils. Following development of the existing subsidence features, access to drainage channels was cut off for a small portion of the hill slope immediately above the subsidence craters. In addition, a number of small drainage channels in the vicinity were intercepted by subsidence craters directly. In order to help reduce the impacts of subsidence features on the collection of surface and subsurface drainage, surface water drainage facilities were installed first in 1969, with additional diversion ditches constructed in July and August of 1981. Of some concern on this project was the potential for losses from unlined diversion

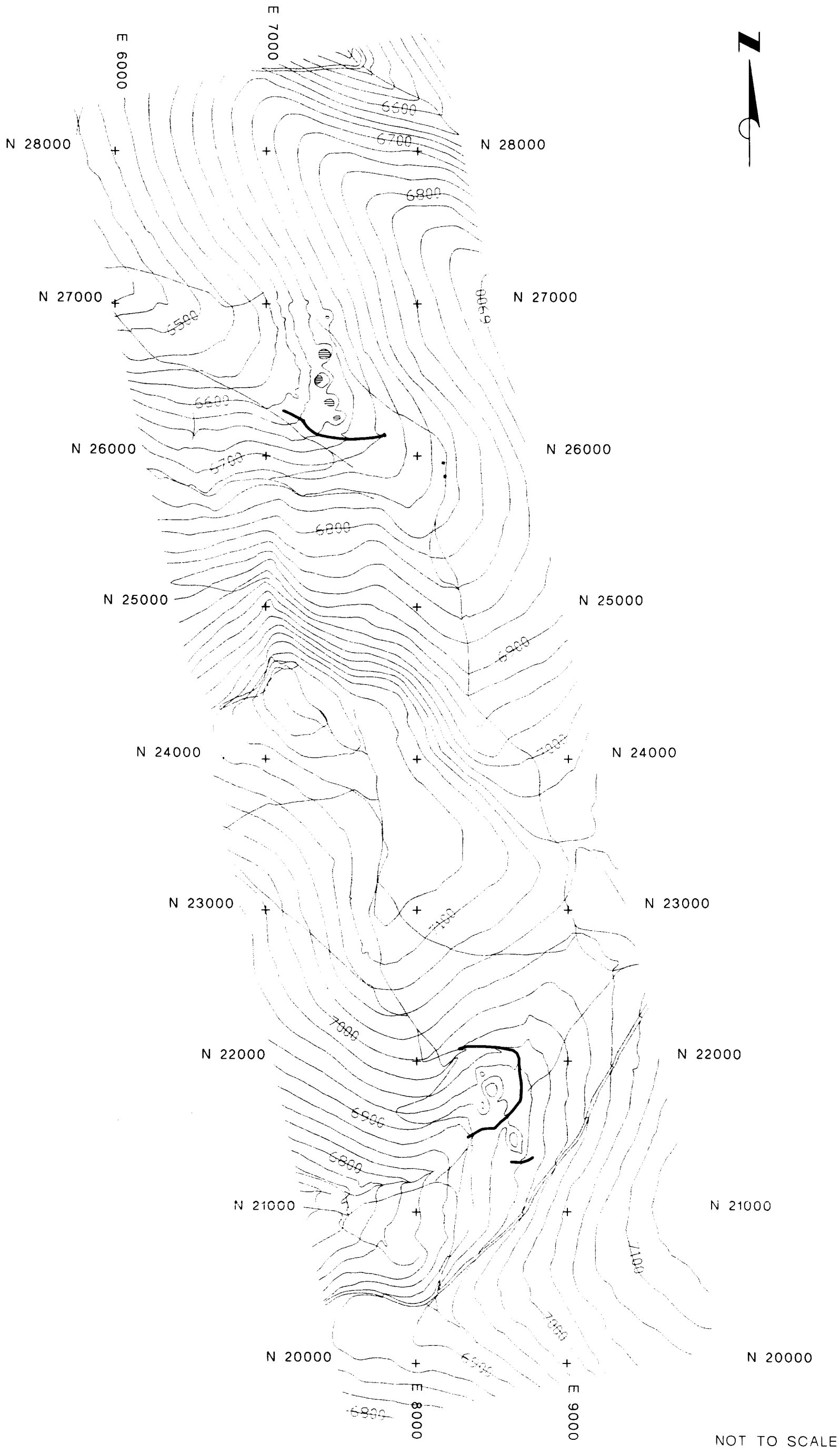

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FIGURE 7-1

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WALKER MINE
W3E PHASE 1

SUBSIDENCE AREA
DIVERSION CHANNELS

channels as these channels crossed the potentially fractured trough s sinkhole features. A series of simple shallow infiltration tests were within this zone and outside of this zone in order to evaluate the p permeability and seepage losses from more intense fracturing within t This testing showed no significant difference between permeability/infil within the limits of the subsidence trough near sinkhole features and th of the subsidence trough distant from sinkhole features. Typical infiltrat to be on the order of 1×10^{-3} cm/s.

Scale & length of tests?

7.2 SURFACE WATER DIVERSION IN UNLINED CHANNELS

As stated above, this type of diversion system is already in use and diverts approximately 77 percent of surface runoff for the mean conditions.

The percentage of surface water intercepted could be increased to 100 percent (with approximately 79 percent being successfully diverted) by the addition of 1,000 lineal feet of new channel.

The addition of channel to intercept all surface runoff would increase current diversion system as shown in Table 7-1.

where's new channel go? USFS property.

TABLE 7-1
UNLINED CHANNEL EFFICIENCY

	EFFICIENCY BEFORE ADDITION * +	EFFICIENCY AFTER ADDITION * +
@ 5 Percent exceedence runoff volume	86.9 percent (219,524,557)	94.0 percent (237,631,979)
@ 50 percent exceedence runoff volume	76.7 percent (34,218,300)	79.4 percent (35,385,191)

* Efficiency is based on the percentage of water diverted that would have entered the sinkholes in the case of no diversion channels.

\+ Numbers in parentheses are the volumes of water, in cubic feet, that are diverted.

channels as these channels crossed the potentially fractured trough subsidence zone near the sinkhole features. A series of simple shallow infiltration tests were conducted at sites both within this zone and outside of this zone in order to evaluate the potential for increase of permeability and seepage losses from more intense fracturing within the subsidence trough. This testing showed no significant difference between permeability/infiltration rates observed within the limits of the subsidence trough near sinkhole features and those observed outside of the subsidence trough distant from sinkhole features. Typical infiltration rates were found to be on the order of 1×10^{-3} cm/s.

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The addition of channel to intercept all surface runoff would increase the efficiency of the current diversion system as shown in Table 7-1.

TABLE 7-1
UNLINED CHANNEL EFFICIENCY

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@ 50 percent exceedence runoff volume	76.7 percent (34,218,300)	79.4 percent (35,385,191)

* Efficiency is based on the percentage of water diverted that would have entered the sinkholes in the case of no diversion channels.

\+ Numbers in parentheses are the volumes of water, in cubic feet, that are diverted.

flow in ditch;
⇒ size of cobbles
snow melt ≈ <4 cfs
ppt = ~700 cfs.

7.3 "CLAY" LINED DIVERSION CHANNELS

Alternative number 2 involves increasing the efficiency of the unlined diversion channels by lining them with a clay soil of sufficiently low permeability as to significantly reduce the infiltration losses from the floor of the channel. This alternative would consist of placing a minimum 6-inch thick layer of low permeability soil (i.e., permeability less than 1E-6 cm/s) in the channel bottom to reduce losses. This layer would require a protective covering of riprap to keep the channel from eroding. The riprap blanket would need to be 18 inches thick to provide adequate protection. The riprap would be underlain by a heavy needle-punched filter fabric to prevent undermining of the riprap during high flows. In order to maintain a 5-foot deep channel, the existing diversion would need to be overexcavated to 24 inches to allow room for both the soil liner and riprap. Reno Mattress is a gabion-like wire basket 9-inches thick which permits the use of riprap-like erosion protection with the use of significantly smaller rock (8-inches maximum diameter instead of 18-inches maximum diameter). Use of Reno Mattress would reduce the overexcavation requirement from 24 inches to 15 inches. Filter fabric would still be required beneath the Reno Mattress.

Using this alternative would increase the efficiency of the diversion system as shown in Table 7-2.

TABLE 7-2
"CLAY" LINED CHANNEL EFFICIENCY

	EFFICIENCY BEFORE ADDITION * +	EFFICIENCY AFTER ADDITION * +
@ 5 Percent exceedence runoff volume	90.9 percent (229,633,683)	99.8 percent (252,335,73)
@ 50 percent exceedence runoff volume	90.7 percent (40,436,918)	97.4 percent (44,430,171)

* Efficiency is based on the percentage of water diverted that would have entered the sinkholes in the case of no diversion channels.
\+ Numbers in parentheses are the volumes of water, in cubic feet, that are diverted.

7.4 GEOSYNTHETICALLY LINED DIVERSION CHANNELS

Alternative number 3 involves increasing the efficiency of the unlined channels by lining them with a geosynthetic material such as high density polyethylene (HDPE). This would consist of placing a 60-mil HDPE liner across the channel bottom to eliminate infiltration losses. The liner would require some form of protection to hold it in place and reduce flow velocity. This protection would be in the form of Reno Mattress. Once again the alternative would be require overexcavating the channels by 9 inches to allow room for the HDPE and Reno Mattress. The use of HDPE and Reno Mattress would increase efficiency of the diversion system by approximately one-tenth of one percent over the clay liner option (Alternative number 2). This is reflected in the results presented in Table 7-3.

TABLE 7-3
GEOSYNTHETICALLY LINED CHANNEL EFFICIENCY

	EFFICIENCY BEFORE ADDITION * +	EFFICIENCY AFTER ADDITION * +
@ 5 Percent exceedence runoff volume	90.9 percent (229,659,003)	99.9 percent (252,372,531)
@ 50 percent exceedence runoff volume	90.7 percent (40,453,798)	97.5 percent (44,454,723)

* Efficiency is based on the percentage of water diverted that would have entered the sinkholes in the case of no diversion channels.
\+ Numbers in parentheses are the volumes of water, in cubic feet, that are diverted.

7.5 SUBSURFACE DRAINS

Alternative number 4 would be to install subsurface intercept drains in order to catch and divert any water migrating through the alluvial soils upgradient of the sinkholes. This alternative would consist of placing perforated ADS pipe at the interface between the alluvial soil and the underlying bedrock/residual soil. This pipe would direct water through the soil and deposit it in the diversion channels. Use of this alternative would catch and successfully direct the remaining 0.1 percent of runoff (355,213 cf for the 5 percent exceedence interval and 136,216 cf for the 50 percent exceedence interval).

8.0 COST BENEFIT ANALYSIS

In order to estimate the cost versus benefit relationship for each of these alternatives, WESTEC has estimated the costs that would be involved in constructing and retrofitting the existing channels to accomplish each alternative. Results of these estimates are summarized in Table 8.1 (a detailed summary of each alternative is presented in Appendix A).

TABLE 8-1
SUMMARY OF ALTERNATIVE COSTS

ALTERNATIVE	COST OF RETROFITTING EXISTING DIVERSIONS ($)	COST OF CONSTRUCTING ADDITIONAL DIVERSION ($)	TOTAL COST ($)
Unlined Diversion	4,972	4,490	9,462
Clay Lining Diversion	288,147	132,928	421,074
HDPE Lining Diversion	307,573	139,905	447,478
Subsurface Diversion	4,700	4,700	4,700

The impact (i.e., benefit) associated with each alternative is presented in Section 7.0 with respect to water diverted in comparison to the no diversion system baseline case. Given that there are existing diversions, any cost benefit analysis should be made in comparison to the existing system. Using this rational, we have broken the cost/benefit analysis down to cost per gallon of water successfully diverted for each alternative. It should be noted that retrofitting the existing diversion structure and leaving it unlined does not carry any benefit in terms of increased water diversion; however, this level of retrofitting should be considered a bare minimum to make existing channels safe to carry the 100-year, 24-hour rain storm event.

Tables 8.2 and 8.3 summarize the cost/benefit analysis for runoff from snowmelt based on 5 percent and 50 percent exceedence probabilities.

TABLE 8-2
COST/BENEFIT SUMMARY FOR 5 PERCENT EXCEEDENCE LEVEL

Diversion Alternative	Volume of Water Diverted in One Year (cf)	Cost ($)	Cost/Benefit Ratio ($ per gallon)
Retrofit Existing Unlined Diversion System	0	4,972	0.0000
Retrofit Existing Unlined Diversion System and Construct Addition 1,000 Feet	18,107,422	9,462	0.0005
Retrofit Existing Diversion System with Clay Liner and Riprap	10,109,126	288,147	0.0285
Retrofit Existing System and Construct Additional 1,000 Feet with Clay Liner and Riprap	32,811,146	421,074	0.0128
Retrofit Existing Diversion System with HDPE Liner and Gabions	10,134,446	307,573	0.0303
Retrofit Existing Diversion System and Construct Additional 1,000 Feet with HDPE Liner and Gabions	32,847,974	447,478	0.0136
Install Subsurface Drains	355, 213	4,700	0.0132

TABLE 8-3
COST/BENEFIT SUMMARY FOR 50 PERCENT EXCEEDENCE LEVEL

Diversion Alternative	Volume of Water Diverted in One Year (cf)	Cost ($)	Cost/Benefit Ratio ($ per gallon)
Retrofit Existing Unlined Diversion System	0	4,972	0.0000
Retrofit Existing Unlined Diversion System and Construct Addition 1,000 Feet	1,166,891	9,462	0.0081
Retrofit Existing Diversion System with Clay Liner and Riprap	6,218,618	288,147	0.0463
Retrofit Existing System and Construct Additional 1,000 Feet with Clay Liner and Riprap	10,211,871	421,074	0.0412
Retrofit Existing Diversion System with HDPE Liner and Gabions	6,235,498	307,573	0.0493
Retrofit Existing Diversion System and Construct Additional 1,000 Feet with HDPE Liner and Gabions	10,236,423	447,478	0.0437
Install Subsurface Drains	136,216	4,700	0.0345

9.0 RECOMMENDATIONS

As stated earlier in the report, it was realized many years ago that some level of effort must be made to divert as much surface runoff as possible around the sinkholes and convey it downhill. To date, approximately 2,200 lineal feet of channel has been constructed. This diversion system currently diverts approximately 77 percent of the surface runoff away from the sinkholes, assuming mean runoff conditions. Therefore, it can be concluded that the existing diversion system should be expanded and retrofitted to increase the efficiency of the diversion system.

The surface and subsurface diversion alternatives presented in Section 7.0 indicated that the efficiency of the diversion system could be increased to almost 100 percent if additional channel lengths are constructed; all channels are lined with clay or geosynthetic; and a subsurface drain system is installed.

The choice of which alternative to use (clay or geosynthetic) should be based on three criteria: cost, aesthetic quality, and durability. In assessing the two options, the obvious choice is clay. The clay option is more economical than geosynthetics, will fit the environment more naturally, and last longer since no man-made materials will be incorporated in channel construction.

Therefore, the following recommendations are offered:

- Retrofit the existing diversion system with a clay liner and riprap
- Construct an additional 1,000 lineal feet of diversion and line with clay and riprap
- Install subsurface drains to intercept lateral subsurface flow

10.0 REFERENCES

Averill, C.V., 1937. Mineral Resources of Plumas County, California Divisions of Mines, Report 33, No. 2, p.79-143.

Prochnau, J. 1986. Walker Gold-Copper Mine, Plumas County, California, report prepared for Robert Berry, Dec. 10, 1986.

APPENDIX A

WATER BALANCE ANALYSIS SUMMARY

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #1 - NO DIVERSION

INITIAL WATER LEVEL ELEVATION =	6262	FT
EXISTING WATER IN STORAGE =	26,151,384	FT3
DISCHARGE ELEVATION (PIUTE SHAFT C	6560	FT
MAX. PRE-DISCHARGE STORAGE =	34,265,763	FT3

EXCEEDENCE PROBABILITY 95% 95%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	UNCON ELEV
							26,151,384	6262		6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	0	0	0	0	64,861	(64,861)	26,021,662	6253	0.00	6253
JUN	0	0	0	0	64,861	(64,861)	25,956,801	6248	0.00	6248.5
JUL	0	0	0	0	64,861	(64,861)	25,891,940	6244	0.00	6244
AUG	0	0	0	0	64,861	(64,861)	25,827,079	6239	0.00	6239.5
SEP	0	0	0	0	64,861	(64,861)	25,762,218	6235	0.00	6235
OCT	0	0	0	0	64,861	(64,861)	25,697,357	6230	0.00	6230.5
NOV	0	0	0	0	64,861	(64,861)	25,632,496	6229	0.00	6228.659
DEC	0	0	0	0	64,861	(64,861)	25,567,635	6228	0.00	6228.146
JAN	0	0	0	0	64,861	(64,861)	25,502,774	6228	0.00	6227.634
FEB	0	0	0	0	64,861	(64,861)	25,437,913	6227	0.00	6227.122
MAR	0	0	0	0	64,861	(64,861)	25,373,052	6227	0.00	6226.61
TOTA	0	0	0	0	778,332	(778,332)				

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EXCEEDENCE PROBABILITY 66% 66%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	UNCON ELEV
							26,151,384	6262	0.00	6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	13,583,831	0	0	0	64,861	13,518,970	39,605,493	6560	2.03	6690.281
JUN	7,157,945	62,554	0	0	64,861	7,155,638	41,421,401	6560	2.72	6712.241
JUL	0	23,899	0	0	64,861	(40,962)	34,224,801	6560	0.00	6559.657
AUG	0	2,485	0	0	64,861	(62,376)	34,162,425	6559	0.00	6559.134
SEP	0	0	0	0	64,861	(64,861)	34,097,564	6559	0.00	6558.591
OCT	0	0	0	0	64,861	(64,861)	34,032,703	6558	0.00	6558.048
NOV	0	0	22,070	0	64,861	(42,791)	33,989,912	6558	0.00	6557.69
DEC	0	0	88,281	0	64,861	23,420	34,013,332	6558	0.00	6557.886
JAN	0	0	419,337	0	64,861	354,476	34,367,808	6560	0.04	6560.855
FEB	0	0	110,352	0	64,861	45,491	34,311,254	6560	0.02	6560.381
MAR	0	0	176,563	0	64,861	111,702	34,377,465	6560	0.04	6560.936
TOTA	20,741,776	88,938	816,603	0	778,332	20,868,985				

EXCEEDENCE PROBABILITY 50% 50%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	5,344,911	0	0		64,861	5,280,050	31,431,434	6452	0.00	6451.602
MAY	24,489,290	48,056	0		64,861	24,472,485	55,903,919	6560	8.24	8531.739
JUN	11,199,612	77,788	0		64,861	11,212,539	45,478,302	6560	4.27	6940.64
JUL	0	10,372	0		64,861	(54,489)	34,211,274	6560	0.00	6559.544
AUG	0	0	0		64,861	(64,861)	34,146,413	6559	0.00	6559
SEP	0	0	0		64,861	(64,861)	34,081,552	6558	0.00	6558.457
OCT	0	0	0		64,861	(64,861)	34,016,691	6558	0.00	6557.914
NOV	0	0	308,985		64,861	244,124	34,260,815	6560	0.00	6559.959
DEC	0	0	617,971		64,861	553,110	34,813,925	6560	0.21	6564.591
JAN	0	0	1,258,012		64,861	1,193,151	35,458,914	6560	0.45	6569.993
FEB	0	0	573,830		64,861	508,969	34,774,732	6560	0.19	6564.263
MAR	0	0	662,112		64,861	597,251	34,863,014	6560	0.23	6565.002
TOTA	41,033,813	136,216	3,420,910	0	778,332	43,812,607				

EXCEEDENCE PROBABILITY 33% 33%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	7,138,749	15,839	66,211	0	64,861	7,155,938	33,307,322	6542	0.00	6542.195
MAY	36,233,400	80,381	176,573	0	64,861	36,425,493	69,732,815	6560	13.50	10642.23
JUN	15,434,695	77,788	0	0	64,861	15,447,622	49,713,385	6560	5.88	7586.975
JUL	0	12,965	0	0	64,861	(51,896)	34,213,867	6560	0.00	6559.565
AUG	0	0	0	0	64,861	(64,861)	34,149,006	6559	0.00	6559.022
SEP	0	0	0	0	64,861	(64,861)	34,084,145	6558	0.00	6558.479
OCT	0	0	0	0	64,861	(64,861)	34,019,284	6558	0.00	6557.936
NOV	0	0	1,037,308	0	64,861	972,447	34,991,731	6560	0.28	6566.08
DEC	0	0	1,942,195	0	64,861	1,877,334	36,143,097	6560	0.71	6575.724
JAN	0	0	2,780,870	0	64,861	2,716,009	36,981,772	6560	1.03	6597.016
FEB	0	0	1,699,420	0	64,861	1,634,559	35,900,322	6560	0.62	6573.691
MAR	516,609	0	1,589,068	0	64,861	2,040,816	36,306,579	6560	0.78	6577.093
TOTA	59,323,453	186,973	9,291,645	0	778,332	68,023,739				

NO DIVERSION

EXCEEDENCE PROBABILITY 5% 5%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	55,081,632	77,788	1,125,590	0	64,861	56,220,149	82,371,533	6560	18.31	12571.08
MAY	66,252,862	80,381	1,589,068	0	64,861	67,857,450	102,123,213	6560	25.83	15585.47
JUN	26,648,095	77,788	2,184,969	0	64,861	28,845,991	63,111,754	6560	10.98	9631.758
JUL	0	15,558	44,140	0	64,861	(5,163)	34,260,600	6560	0.00	6559.957
AUG	0	0	595,900	0	64,861	531,039	34,791,639	6560	0.20	6564.405
SEP	0	0	331,056	0	64,861	266,195	34,531,958	6560	0.10	6562.23
OCT	0	0	3,310,560	0	64,861	3,245,699	37,511,462	6560	1.24	6646.184
NOV	0	0	6,334,204	0	64,861	6,269,343	40,535,106	6560	2.39	6696.306
DEC	258,304	0	13,242,240	0	64,861	13,435,683	47,701,446	6560	5.11	7279.924
JAN	4,629,607	0	10,968,988	0	64,861	15,533,734	49,799,497	6560	5.91	7600.117
FEB	16,766,536	23,617	8,651,596	0	64,861	25,376,888	59,642,651	6560	9.66	9102.323
MAR	27,736,064	80,081	6,621,120	0	64,861	34,372,404	68,638,167	6560	13.08	10475.17
TOTA	197,373,100	355,213	54,999,431	0	778,332	251,949,412				

$\sum_{IN}$ = 252,727,744 ft³

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #1 - UNLINED DIVERSION

INITIAL WATER LEVEL ELEVATION =	6262	FT
EXISTING WATER IN STORAGE =	26,151,384	FT3
DISCHARGE ELEVATION (PIUTE SHAFT C	6560	FT
MAX. PRE-DISCHARGE STORAGE =	34,265,763	FT3

EXCEEDENCE PROBABILITY 95% 95%

MONT	RUNOFF FR SNOWMELT (FT3)	SUBSURFA DISCHAR (FT3)	RUNOFF FR PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	UNCON ELEV
							26,151,384	6262		6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	0	0	0	0	64,861	(64,861)	26,021,662	6253	0.00	6253
JUN	0	0	0	0	64,861	(64,861)	25,956,801	6248	0.00	6248.5
JUL	0	0	0	0	64,861	(64,861)	25,891,940	6244	0.00	6244
AUG	0	0	0	0	64,861	(64,861)	25,827,079	6239	0.00	6239.5
SEP	0	0	0	0	64,861	(64,861)	25,762,218	6235	0.00	6235
OCT	0	0	0	0	64,861	(64,861)	25,697,357	6230	0.00	6230.5
NOV	0	0	0	0	64,861	(64,861)	25,632,496	6229	0.00	6228.659
DEC	0	0	0	0	64,861	(64,861)	25,567,635	6228	0.00	6228.146
JAN	0	0	0	0	64,861	(64,861)	25,502,774	6228	0.00	6227.634
FEB	0	0	0	0	64,861	(64,861)	25,437,913	6227	0.00	6227.122
MAR	0	0	0	0	64,861	(64,861)	25,373,052	6227	0.00	6226.61
TOTA	0	0	0	0	778,332	(778,332)				

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EXCEEDENCE PROBABILITY 66% 66%

MONT	RUNOFF FR SNOWMELT (FT3)	SUBSURFA DISCHAR (FT3)	RUNOFF FR PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	UNCON ELEV
							26,151,384	6262	0.00	6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	0	0	0	1,018,150	64,861	953,289	27,039,812	6305	0.00	6304.534
JUN	0	62,554	0	1,018,150	64,861	1,015,843	28,055,655	6348	0.00	6348.155
JUL	0	23,899	0	0	64,861	(40,962)	28,014,693	6344	0.00	6343.6
AUG	0	2,485	0	0	64,861	(62,376)	27,952,317	6337	0.00	6336.664
SEP	0	0	0	0	64,861	(64,861)	27,887,456	6329	0.00	6329.452
OCT	0	0	0	0	64,861	(64,861)	27,822,595	6322	0.00	6322.239
NOV	0	0	0	22,070	64,861	(42,791)	27,779,804	6317	0.00	6317.481
DEC	0	0	0	88,281	64,861	23,420	27,803,224	6320	0.00	6320.085
JAN	0	0	0	419,337	64,861	354,476	28,157,700	6360	0.00	6359.502
FEB	0	0	0	110,352	64,861	45,491	28,203,191	6365	0.00	6364.56
MAR	0	0	0	176,563	64,861	111,702	28,314,893	6377	0.00	6376.981
TOTA	0	88,938	0	2,852,903	778,332	2,163,509				

EXCEEDENCE PROBABILITY 50% 50%

MONT	RUNOFF FR SNOWMELT (FT3)	SUBSURFA DISCHAR (FT3)	RUNOFF FR PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	0	0	0	1,018,150	64,861	953,289	27,104,673	6305	0.00	6305.061
MAY	0	48,056	0	1,018,150	64,861	1,001,345	28,106,018	6354	0.00	6353.755
JUN	0	77,788	0	1,018,150	64,861	1,031,077	29,137,095	6430	0.00	6430.435
JUL	0	10,372	0		64,861	(54,489)	29,082,606	6430	0.00	6429.933
AUG	0	0	0		64,861	(64,861)	29,017,745	6429	0.00	6429.334
SEP	0	0	0		64,861	(64,861)	28,952,884	6429	0.00	6428.736
OCT	0	0	0		64,861	(64,861)	28,888,023	6428	0.00	6428.138
NOV	0	0	0	308,985	64,861	244,124	29,132,147	6430	0.00	6430.39
DEC	0	0	0	617,971	64,861	553,110	29,685,257	6435	0.00	6435.493
JAN	0	0	0	1,018,150	64,861	953,289	30,638,546	6444	0.00	6444.287
FEB	0	0	0	573,830	64,861	508,969	31,147,515	6449	0.00	6448.983
MAR	0	0	0	662,112	64,861	597,251	31,744,766	6454	0.00	6454.493
TOTA	0	136,216	0	6,235,498	778,332	5,593,382				

EXCEEDENCE PROBABILITY 33% 33%

MONT	RUNOFF FR SNOWMELT (FT3)	SUBSURFA DISCHAR (FT3)	RUNOFF FR PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	0	15,839	0	1,018,150	64,861	969,128	27,120,512	6305	0.00	6305.19
MAY	0	80,381	0	1,018,150	64,861	1,033,670	28,154,182	6359	0.00	6359.111
JUN	0	77,788	0	1,018,150	64,861	1,031,077	29,185,259	6431	0.00	6430.88
JUL	0	12,965	0	0	64,861	(51,896)	29,133,363	6430	0.00	6430.401
AUG	0	0	0	0	64,861	(64,861)	29,068,502	6430	0.00	6429.803
SEP	0	0	0	0	64,861	(64,861)	29,003,641	6429	0.00	6429.204
OCT	0	0	0	0	64,861	(64,861)	28,938,780	6429	0.00	6428.606
NOV	0	0	0	1,018,150	64,861	953,289	29,892,069	6437	0.00	6437.401
DEC	0	0	0	1,018,150	64,861	953,289	30,845,358	6446	0.00	6446.195
JAN	0	0	0	1,018,150	64,861	953,289	31,798,647	6455	0.00	6454.99
FEB	0	0	0	1,018,150	64,861	953,289	32,751,936	6493	0.00	6493.282
MAR	0	0	0	1,018,150	64,861	953,289	33,705,225	6555	0.00	6555.305
TOTA	0	186,973	0	8,145,200	778,332	7,553,841				

EXCEEDENCE PROBABILITY 5% 5%

UNLINED DIVERSION

MONT	RUNOFF FR SNOWMELT (FT3)	SUBSURFA DISCHAR (FT3)	RUNOFF FR PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	0	77,788	0	1,018,150	64,861	1,031,077	27,182,461	6306	0.00	6305.693
MAY	0	80,381	0	1,018,150	64,861	1,033,670	28,216,131	6366	0.00	6365.999
JUN	0	77,788	0	1,018,150	64,861	1,031,077	29,247,208	6431	0.00	6431.451
JUL	0	15,558	0	44,140	64,861	(5,163)	29,242,045	6431	0.00	6431.404
AUG	0	0	0	595,900	64,861	531,039	29,773,084	6436	0.00	6436.303
SEP	0	0	0	331,056	64,861	266,195	30,039,279	6439	0.00	6438.759
OCT	0	0	0	1,018,150	64,861	953,289	30,992,568	6448	0.00	6447.553
NOV	0	0	0	1,018,150	64,861	953,289	31,945,857	6456	0.00	6456.348
DEC	0	0	0	1,018,150	64,861	953,289	32,899,146	6506	0.00	6506.246
JAN	0	0	0	1,018,150	64,861	953,289	33,852,435	6557	0.00	6556.538
FEB	0	23,617	0	1,018,150	64,861	976,906	34,829,341	6560	0.21	6564.72
MAR	0	80,081	0	1,018,150	64,861	1,033,370	35,299,133	6560	0.39	6568.655
TOTA	0	355,213	0	10,134,446	778,332	9,711,327				

$\Sigma_{IN} = 10,484,695$

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #5 - CLAY LINED DIVERSIONS
EXCEEDENCE PROBABILITY 95% 95%

MONT	RUNOFF F SNOWMEL (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAG LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)
							26,151,384	6262	
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00
MAY	0	0	0	0	64,861	(64,861)	26,021,662	6253	0.00
JUN	0	0	0	0	64,861	(64,861)	25,956,801	6248	0.00
JUL	0	0	0	0	64,861	(64,861)	25,891,940	6244	0.00
AUG	0	0	0	0	64,861	(64,861)	25,827,079	6239	0.00
SEP	0	0	0	0	64,861	(64,861)	25,762,218	6235	0.00
OCT	0	0	0	0	64,861	(64,861)	25,697,357	6230	0.00
NOV	0	0	0	0	64,861	(64,861)	25,632,496	6229	0.00
DEC	0	0	0	0	64,861	(64,861)	25,567,635	6228	0.00
JAN	0	0	0	0	64,861	(64,861)	25,502,774	6228	0.00
FEB	0	0	0	0	64,861	(64,861)	25,437,913	6227	0.00
MAR	0	0	0	0	64,861	(64,861)	25,373,052	6227	0.00
TOTA	0	0	0	0	778,332	(778,332)			

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #5 - CLAY LINED DIVERSIONS
EXCEEDENCE PROBABILITY 66% 66%

MONT	RUNOFF F SNOWMEL (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAG LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)
							26,151,384	6262	0.00
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00
MAY	0	0	0	2,110	64,861	(62,751)	26,023,772	6253	0.00
JUN	0	62,554	0	2,110	64,861	(197)	26,023,575	6253	0.00
JUL	0	23,899	0	0	64,861	(40,962)	25,982,613	6250	0.00
AUG	0	2,485	0	0	64,861	(62,376)	25,920,237	6246	0.00
SEP	0	0	0	0	64,861	(64,861)	25,855,376	6241	0.00
OCT	0	0	0	0	64,861	(64,861)	25,790,515	6237	0.00
NOV	0	0	0	0	64,861	(64,861)	25,725,654	6232	0.00
DEC	0	0	0	0	64,861	(64,861)	25,660,793	6229	0.00
JAN	0	0	0	0	64,861	(64,861)	25,595,932	6228	0.00
FEB	0	0	0	0	64,861	(64,861)	25,531,071	6228	0.00
MAR	0	0	0	0	64,861	(64,861)	25,466,210	6227	0.00
TOTA	0	88,938	0	4,220	778,332	(685,174)			

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #5 - CLAY LINED DIVERSIONS
EXCEEDENCE PROBABILITY 50% 50%

MONT	RUNOFF F SNOWMEL (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAG LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)
							26,151,384	6262	
APR	0	0	0	2,110	64,861	(62,751)	26,088,633	6258	0.00
MAY	0	48,056	0	2,110	64,861	(14,695)	26,073,938	6257	0.00
JUN	0	77,788	0	2,110	64,861	15,037	26,088,975	6258	0.00
JUL	0	10,372	0	0	64,861	(54,489)	26,034,486	6254	0.00
AUG	0	0	0	0	64,861	(64,861)	25,969,625	6249	0.00
SEP	0	0	0	0	64,861	(64,861)	25,904,764	6245	0.00
OCT	0	0	0	0	64,861	(64,861)	25,839,903	6240	0.00
NOV	0	0	0	0	64,861	(64,861)	25,775,042	6236	0.00
DEC	0	0	0	0	64,861	(64,861)	25,710,181	6231	0.00
JAN	0	0	0	0	64,861	(64,861)	25,645,320	6229	0.00
FEB	0	0	0	0	64,861	(64,861)	25,580,459	6228	0.00
MAR	0	0	0	0	64,861	(64,861)	25,515,598	6228	0.00
TOTA	0	136,216	0	6,330	778,332	(635,786)			

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #5 - CLAY LINED DIVERSIONS
EXCEEDENCE PROBABILITY 33% 33%

MONT	RUNOFF F SNOWMEL (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAG LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)
							26,151,384	6262	
APR	0	15,839	0	2,110	64,861	(46,912)	26,104,472	6259	0.00
MAY	0	80,381	0	2,110	64,861	17,630	26,122,102	6260	0.00
JUN	0	77,788	0	2,110	64,861	15,037	26,137,139	6261	0.00
JUL	0	12,965	0	0	64,861	(51,896)	26,085,243	6257	0.00
AUG	0	0	0	0	64,861	(64,861)	26,020,382	6253	0.00
SEP	0	0	0	0	64,861	(64,861)	25,955,521	6248	0.00
OCT	0	0	0	0	64,861	(64,861)	25,890,660	6244	0.00
NOV	0	0	0	0	64,861	(64,861)	25,825,799	6239	0.00
DEC	0	0	0	0	64,861	(64,861)	25,760,938	6235	0.00
JAN	0	0	0	0	64,861	(64,861)	25,696,077	6230	0.00
FEB	0	0	0	0	64,861	(64,861)	25,631,216	6229	0.00
MAR	0	0	0	2,110	64,861	(62,751)	25,568,465	6228	0.00
TOTA	0	186,973	0	8,440	778,332	(582,919)			

CLAY LINED DIVERSION

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #5 - CLAY LINED DIVERSIONS
EXCEEDENCE PROBABILITY 5% 5%

MONT	RUNOFF F SNOWMEL (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAG LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)
							26,151,384	6262	
APR	0	77,788	0	2,110	64,861	15,037	26,166,421	6263	0.00
MAY	0	80,381	0	2,110	64,861	17,630	26,184,051	6264	0.00
JUN	0	77,788	0	2,110	64,861	15,037	26,199,088	6265	0.00
JUL	0	15,558	0	0	64,861	(49,303)	26,149,785	6262	0.00
AUG	0	0	0	0	64,861	(64,861)	26,084,924	6257	0.00
SEP	0	0	0	0	64,861	(64,861)	26,020,063	6253	0.00
OCT	0	0	0	0	64,861	(64,861)	25,955,202	6248	0.00
NOV	0	0	0	0	64,861	(64,861)	25,890,341	6244	0.00
DEC	0	0	0	2,110	64,861	(62,751)	25,827,590	6240	0.00
JAN	0	0	0	2,110	64,861	(62,751)	25,764,839	6235	0.00
FEB	0	23,617	0	2,110	64,861	(39,134)	25,725,705	6232	0.00
MAR	0	80,081	0	2,110	64,861	17,330	25,743,035	6234	0.00
TOTA	0	355,213	0	14,770	778,332	(408,349)			

$\Sigma_{12} = 369,933$

WALKER MINE #3
SUMMARY OF PROBABLE WATER LEVELS WITHIN MINE FOR VARIOUS ALTERNATIVES
ALTERNATIVE: #1 - PLASTIC LINED DIVERSION

INITIAL WATER LEVEL ELEVATION =	6262	FT
EXISTING WATER IN STORAGE =	26,151,384	FT3
DISCHARGE ELEVATION (PIUTE SHAFT C	6560	FT
MAX. PRE-DISCHARGE STORAGE =	34,265,763	FT3

EXCEEDENCE PROBABILITY 95% 95%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	UNCON ELEV
							26,151,384	6262		6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	0	0	0	0	64,861	(64,861)	26,021,662	6253	0.00	6253
JUN	0	0	0	0	64,861	(64,861)	25,956,801	6248	0.00	6248.5
JUL	0	0	0	0	64,861	(64,861)	25,891,940	6244	0.00	6244
AUG	0	0	0	0	64,861	(64,861)	25,827,079	6239	0.00	6239.5
SEP	0	0	0	0	64,861	(64,861)	25,762,218	6235	0.00	6235
OCT	0	0	0	0	64,861	(64,861)	25,697,357	6230	0.00	6230.5
NOV	0	0	0	0	64,861	(64,861)	25,632,496	6229	0.00	6228.659
DEC	0	0	0	0	64,861	(64,861)	25,567,635	6228	0.00	6228.146
JAN	0	0	0	0	64,861	(64,861)	25,502,774	6228	0.00	6227.634
FEB	0	0	0	0	64,861	(64,861)	25,437,913	6227	0.00	6227.122
MAR	0	0	0	0	64,861	(64,861)	25,373,052	6227	0.00	6226.61
TOTA	0	0	0	0	778,332	(778,332)				

EXCEEDENCE PROBABILITY 66% 66%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	UNCON ELEV
							26,151,384	6262	0.00	6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	0	0	0	0	64,861	(64,861)	26,021,662	6253	0.00	6253
JUN	0	62,554	0	0	64,861	(2,307)	26,019,355	6253	0.00	6252.84
JUL	0	23,899	0	0	64,861	(40,962)	25,978,393	6250	0.00	6249.998
AUG	0	2,485	0	0	64,861	(62,376)	25,916,017	6246	0.00	6245.67
SEP	0	0	0	0	64,861	(64,861)	25,851,156	6241	0.00	6241.17
OCT	0	0	0	0	64,861	(64,861)	25,786,295	6237	0.00	6236.67
NOV	0	0	0	0	64,861	(64,861)	25,721,434	6232	0.00	6232.17
DEC	0	0	0	0	64,861	(64,861)	25,656,573	6229	0.00	6228.849
JAN	0	0	0	0	64,861	(64,861)	25,591,712	6228	0.00	6228.337
FEB	0	0	0	0	64,861	(64,861)	25,526,851	6228	0.00	6227.824
MAR	0	0	0	0	64,861	(64,861)	25,461,990	6227	0.00	6227.312
TOTA	0	88,938	0	0	778,332	(689,394)				

EXCEEDENCE PROBABILITY 50% 50%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	0	0	0	0	64,861	(64,861)	26,086,523	6257	0.00	6257.5
MAY	0	48,056	0	0	64,861	(16,805)	26,069,718	6256	0.00	6256.334
JUN	0	77,788	0	0	64,861	12,927	26,082,645	6257	0.00	6257.231
JUL	0	10,372	0	0	64,861	(54,489)	26,028,156	6253	0.00	6253.451
AUG	0	0	0	0	64,861	(64,861)	25,963,295	6249	0.00	6248.951
SEP	0	0	0	0	64,861	(64,861)	25,898,434	6244	0.00	6244.451
OCT	0	0	0	0	64,861	(64,861)	25,833,573	6240	0.00	6239.951
NOV	0	0	0	0	64,861	(64,861)	25,768,712	6235	0.00	6235.451
DEC	0	0	0	0	64,861	(64,861)	25,703,851	6231	0.00	6230.951
JAN	0	0	0	0	64,861	(64,861)	25,638,990	6229	0.00	6228.71
FEB	0	0	0	0	64,861	(64,861)	25,574,129	6228	0.00	6228.198
MAR	0	0	0	0	64,861	(64,861)	25,509,268	6228	0.00	6227.686
TOTA	0	136,216	0	0	778,332	(642,116)				

EXCEEDENCE PROBABILITY 33% 33%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	0	15,839	0	0	64,861	(49,022)	26,102,362	6259	0.00	6258.599
MAY	0	80,381	0	0	64,861	15,520	26,117,882	6260	0.00	6259.676
JUN	0	77,788	0	0	64,861	12,927	26,130,809	6261	0.00	6260.573
JUL	0	12,965	0	0	64,861	(51,896)	26,078,913	6257	0.00	6256.972
AUG	0	0	0	0	64,861	(64,861)	26,014,052	6252	0.00	6252.472
SEP	0	0	0	0	64,861	(64,861)	25,949,191	6248	0.00	6247.972
OCT	0	0	0	0	64,861	(64,861)	25,884,330	6243	0.00	6243.472
NOV	0	0	0	0	64,861	(64,861)	25,819,469	6239	0.00	6238.972
DEC	0	0	0	0	64,861	(64,861)	25,754,608	6234	0.00	6234.472
JAN	0	0	0	0	64,861	(64,861)	25,689,747	6230	0.00	6229.972
FEB	0	0	0	0	64,861	(64,861)	25,624,886	6229	0.00	6228.598
MAR	0	0	0	0	64,861	(64,861)	25,560,025	6228	0.00	6228.086
TOTA	0	186,973	0	0	778,332	(591,359)				

PLASTIC LINED DIVERSIONS

EXCEEDENCE PROBABILITY 5% 5%

MONT	RUNOFF F SNOWMELT (FT3)	SUBSURF DISCHAR (FT3)	RUNOFF F PRECIP (FT3)	LEAKAGE F DIVERSION (FT3)	SEEPAGE LOSS (FT3)	NET CHANGE (FT3)	END OF MO STORAGE (FT3)	END OF MO ELEVATION (ft)	MEAN MONTHLY DISCHARGE (FT3/SEC)	
							26,151,384	6262		6262
APR	0	77,788	0	0	64,861	12,927	26,164,311	6263	0.00	6262.897
MAY	0	80,381	0	0	64,861	15,520	26,179,831	6264	0.00	6263.974
JUN	0	77,788	0	0	64,861	12,927	26,192,758	6265	0.00	6264.87
JUL	0	15,558	0	0	64,861	(49,303)	26,143,455	6261	0.00	6261.45
AUG	0	0	0	0	64,861	(64,861)	26,078,594	6257	0.00	6256.95
SEP	0	0	0	0	64,861	(64,861)	26,013,733	6252	0.00	6252.45
OCT	0	0	0	0	64,861	(64,861)	25,948,872	6248	0.00	6247.95
NOV	0	0	0	0	64,861	(64,861)	25,884,011	6243	0.00	6243.45
DEC	0	0	0	0	64,861	(64,861)	25,819,150	6239	0.00	6238.95
JAN	0	0	0	0	64,861	(64,861)	25,754,289	6234	0.00	6234.45
FEB	0	23,617	0	0	64,861	(41,244)	25,713,045	6232	0.00	6231.588
MAR	0	80,081	0	0	64,861	15,220	25,728,265	6233	0.00	6232.644
TOTA	0	355,213	0	0	778,332	(423,119)				

$\Sigma_{IN} = 355,213$

APPENDIX B

ALTERNATIVE COST ESTIMATES

ASSUMPTIONS FOR ENGINEERS ESTIMATE

1. Excavation assumed using a D7 or equivalent.

2. Compaction assumed using a sheeps foot roller compacting 6" lifts using four passes.

3. Haul costs assume a 40 mile round trip and adjusted for rough and steep terrain. Means cost estimator does not have 40 mile round trip costs, so looking at values for the range they give, I extrapolated (1.75 × 20 mile values).

4. Clay and riprap are assumed to be hauled in.

5. Trenching for subsurface diversions assumes all trenches are 1' wide and 5' deep, and includes backfilling and compaction of 6" lifts using a wacker.

6. HDPE is assumed to be 60 mil. The price is based on the $0.51/sf price @ Disposal Services Lockweel landfill for ≈130,000 sf, I increased this price by 25% to use here.

Was a clay borrow source identified w/in 20 miles of site. How would cost change if clay comes from Reno? & of HDPE

ASSUMPTIONS FOR ENGINEERS ESTIMATE

1. Excavation assumed using a D7 or equivalent.

2. Compaction assumed using a sheeps foot roller compacting 6" lifts using four passes.

3. Haul costs assume a 40 mile round trip and adjusted for rough and steep terrain. Means cost estimator does not have 40 mile round trip costs, so looking at values for the range they give, I extrapolated (1.75 × 20 mile values).

4. Clay and riprap are assumed to be hauled in.

5. Trenching for subsurface diversions assumes all trenches are 1' wide and 5' deep, and includes backfilling and compaction of 6" lifts using a wacker.

6. HDPE is assumed to be 60 mil. The price is based on the $0.51/sf price @ Disposal Services Lockweel landfill for ≈130,000 sf, I increased this price by 25% to use here.

WALKER 3 - SURFACE DIVERSION ALTERNATIVES COST ESTIMATE SUMMARY SHEE
PROJ 19904-15
NCK 04/28/93

ALTERNATIVE	EXISTING DIVERSION	ADDITIONAL DIVERSION	TOTAL
UNLINED	$4,972	$4,490	$9,462
CLAY LINING	$288,147	$132,928	$421,074
HDPE LINING	$307,573	$139,905	$447,478
SUBSURFACE	$4,700		$4,700

WALKER 3 - DIVERSION ALTERNATIVE CONSTRUCTION & MATERIALS COST ESTIMATE WORK
PROJ 19904-15
NCK 04/26/93

CATAGORY	UNIT	UNIT COST	
SITE EXCAVATION	CY	$1.020	
SUBGRADE PREP	SF	$0.020	
RIP RAP	CY	$67.050	
RENO MATRESS	CY	$127.500	
CLAY LINER	CY	$14.630	
TRENCHING	LF	$1.200	(1' WIDE & 5' DEEP)
HDPE	SF	$0.640	
3" ADS HIWAY PIPE	LF	$0.600	

ESTIMATES ASSUME ALL COSTS TO ACHIEVE FINISHED PRODUCT

WALKER 3 - DIVERSION ALTERNATIVE CONSTRUCTION & MATERIALS COST ESTIMATE WORK SHEET
********** REHAB OF EXISTING SURFACE DIVERSION OPTION **********
PROJ 19904-15
NCK 04/26/93

ITEM	QUANTITY	COST
SITE EXCAVATION	2,075	$2,117
SUBGRADE PREP	42,750	$855
MOB	1	$2,000
SUB-TOTAL		$4,972

********** ADDITION OF 1000 FEET OF SURFACE DIVERSION OPTION **********

ITEM	QUANTITY	COST
SITE EXCAVATION	2,000	$2,040
SUBGRADE PREP	22,500	$450
MOB	1	$2,000
SUB-TOTAL		$4,490

TOTAL OF BOTH OPTIONS $9,462

WALKER 3 - DIVERSION ALTERNATIVE CONSTRUCTION & MATERIALS COST ESTIMATE WORK SHEET
********** CLAY LINING OF EXISTING SURFACE DIVERSION OPTION **********
PROJ 19904-15
NCK 04/26/93

ITEM	QUANTITY	COST
CLAY LINER	1,300	$19,019
RIP RAP	3,850	$258,143
SUB-GRADE PREP	69,300	$1,386
SITE EXCAVATION	7,450	$7,599
MOB	1	$2,000
SUB-TOTAL		$288,147

********** CLAY LINING AND CONSTRUCTION OF ADDITIONAL 1000 FEET OF SURFACE DIVERSION OPTION ***

ITEM	QUANTITY	COST
CLAY LINER	600	$8,778
RIP RAP	1,750	$117,338
SUB-GRADE PREP	31,500	$630
SITE EXCAVATION	4,100	$4,182
MOB	1	$2,000
SUB-TOTAL		$132,928
TOTAL		$421,074

WALKER 3 - DIVERSION ALTERNATIVE CONSTRUCTION & MATERIALS COST ESTIMATE WORK SHEET
********** PLASTIC LINING OF EXISTING SURFACE DIVERSION OPTION **********
PROJ 19904-15
NCK 04/26/93

ITEM	QUANTITY	COST
HDPE LINER	66,000	$42,240
RENO MATTRESS	2,000	$255,000
SUB-GRADE PREP	66,000	$1,320
SITE EXCAVATION	6,875	$7,013
MOB	1	$2,000
SUB-TOTAL		$307,573

********** PLASTIC LINING AND CONSTRUCTION OF ADDITIONAL 1000' OF SURFACE DIVERSION OPTION *****

ITEM	QUANTITY	COST
HDPE LINER	30,000	$19,200
RENO MATTRESS	900	$114,750
SUB-GRADE PREP	32,000	$640
SITE EXCAVATION	3,250	$3,315
MOB	1	$2,000
SUB-TOTAL		$139,905
TOTAL		$447,478

WALKER 3 - DIVERSION ALTERNATIVE CONSTRUCTION & MATERIALS COST ESTIMATE WORK
********** SUBSURFACE DIVERSION OPTION **********
PROJ 19904-15
NCK 04/26/93

ITEM	QUANTITY	COST
MOB	1	$2,000
TRENCHING	1500	$1,800
3" ADS HIWAY PIPE	1500	$900
TOTAL		$4,700

STATE OF CALIFORNIA

INTERAGENCY AGREEMENT

STD. 13 (REV. 9-89)

NUMBER
6-068-150-0

THIS AGREEMENT is entered into this 11th day of March, 1997, by and between the undersigned State Agencies:

Set forth services, materials, or equipment to be furnished, or work to be performed, and by whom, time for performance including the terms, date of commencement and date of completion, and provision for payment per (1225 and 8752-8752.1 SAM.)

Distribution:

- [ ] Agency providing services
- [ ] Agency receiving services
- [ ] Department of General Services (unless exempt from DGS approval)
- [ ] Controller

1. The Contractor agrees to provide all labor, materials and equipment necessary to install a monitoring well into the Walker Mine workings in accordance with the terms and conditions contained herein and all exhibits attached hereto. Performance of services pursuant to the requirements of this agreement shall conform to high professional standards. The Standard Form No. 13 provisions and all documents incorporated are essential terms of this agreement and a requirement in one shall be as binding as though occurring in all. All parts of the agreement are intended to be complementary and together describe and provide for the materials or services contracted for.

   The Contractor shall at all times comply with all applicable state laws, rules, regulations and local ordinances specifically including but not limited to environmental, procurement and safety laws, rules, regulations and ordinances.

(continued)

(Continued on ____ sheets which are hereby attached and made a part hereof)

NAME OF STATE AGENCY RECEIVING SERVICES State Water Resources Control Board	NAME OF STATE AGENCY PROVIDING SERVICES Department of Water Resources
CALLED ABOVE (SHORT NAME) State Water Board	CALLED ABOVE (SHORT NAME) Contractor/Agency
AUTHORIZED SIGNATURE >	AUTHORIZED SIGNATURE >
PRINTED NAME AND TITLE OF PERSON SIGNING Bill Brown, Chief Division of Administrative Services	PRINTED NAME AND TITLE OF PERSON SIGNING
FUND NUMBER AND NAME	FUND NUMBER AND NAME

AMOUNT ENCUMBERED BY THIS DOCUMENT $40,000.00	PROGRAM/CATEGORY (CODE AND TITLE) 99	FUND TITLE General		
PRIOR AMOUNT ENCUMBERED FOR THIS CONTRACT $ 0	(OPTIONAL USE)			
TOTAL AMOUNT ENCUMBERED TO DATE $40,000.00	ITEM 3940-001-001	CHAPTER 162	STATUTE 1996	FISCAL YEAR 96/97
	OBJECT OF EXPENDITURE (CODE AND TITLE) 0150 569-01 13305 $40,000.00			

Department of General Services Use Only

This contract exempt from DGS review in accordance with SWRCB Water Code Section 13304.

I hereby certify upon my own personal knowledge that budgeted funds are available for the period and purpose of the expenditure stated above.

T.B.A. NO.

B.

SIGNATURE OF ACCOUNTING OFFICER
X

DATE

6075301100

2. Documents Incorporated:

The following documents are hereby incorporated and made a part of this agreement by reference:

Exhibit "A" entitled General Provisions;
Attachment "One" to Exhibit "A" entitled Federal Provisions;
Exhibit "B" entitled Scope of Work; and
Exhibit "C" entitled Budget.

In the event of any inconsistency in the provisions of this agreement, the inconsistency shall be resolved by giving precedence in the following order: (1) Standard Form No. 13; (2) Exhibit A (General Provisions); (3) Exhibit B (Scope of Work); and (4) Exhibit C (Budget).

3. Term:

Term of this agreement shall be from May 1, 1997 through December 31, 1997. The Contractor shall not be entitled to payment for any work done prior to the commencement date.

4. Definitions:

a. The term "State Water Board" means the California State Water Resources Control Board.

b. The term "Regional Board" means the California Regional Water Quality Control Board, Centeral Valley Region. This agreement is being entered into by the State Water Board on behalf of the Regional Board.

c. The term "Contractor/Agency" means State Department of Water Resources.

5. Payment Provisions:

a. Cost and Payment: Upon satisfactory completion of all work performed under this agreement, the State Water Board agrees to reimburse the Contractor an amount equal to the latter's cost of performance hereunder computed in accordance with Section 8752 of the State Administrative Manual. In no event shall the total amount paid to the Agency under this agreement exceed eighty-three thousand five hundred and ninty-two dollars ($83,592.00) as set forth in Exhibit C.

(1) Total payment to the Contractor prior to July 1, 1997 shall not exceed forty thousand dollars ($40,000).

(2) Total payment to the Contractor prior to July 1, 1998 shall not exceed eighty three thousand five hundred and ninety-two dollars ($83,592.00).

b. Limitation of State Liability: The maximum amount to be encumbered under this agreement for the 1996-97 fiscal year ending June 30, 1997 shall not exceed $40,000.00. Any requirement of performance by the State and the Contractor for the period of the agreement subsequent to June 30, 1997 will be dependent upon the availability of future appropriations by the Legislature for the purpose of this agreement. If funds become available from future appropriations by the Legislature for purposes of this agreement, the maximum amount to be encumbered for this agreement in the 1997-98 fiscal year ending June 30, 1998 shall not exceed forty-three thousand five hundred and ninety two dollars $43,592.00.

c. Funding or Funding Reduction in Subsequent Fiscal Years: The State's obligation for performance of this agreement is contingent upon the availability of funds appropriated by the Legislature from which payment for agreement purposes can be made. No legal liability for any payment on the part of the State may arise for performance under this agreement until sufficient funds are made available for the purpose of this agreement.

If funding for any fiscal year is reduced or deleted by the Legislature for purposes of this program, the State shall have the option to either: cancel this agreement with no liability occurring to the State, or offer an agreement amendment to the Contractor to reflect the reduced amount.

6. Invoicing Procedures:

a. The Contractor shall be paid in arrears, on a monthly basis, upon submission of an original and two copies of the invoice which properly details all charges, expenses, direct and indirect costs in accordance with Exhibit C. Invoices shall be submitted to:

Patrick Morris
Regional Water Quality Control Board
Central Valley Region
3443 Routier Road
Sacramento, CA 95827-3098

The original and one (1) approved copy of the invoice or payment request will be forwarded to the State Water Board's Accounting Operations Section. Invoices shall be paid within 50 calendar days. Payment of any invoice will be made only after receipt of a complete, adequately supported, properly documented and accurately addressed invoice or payment request.

Failure to use the address exactly as provided above may result in return of the invoice or payment request to the Contractor. Payment shall be deemed complete upon deposit of the payment, properly addressed, postage prepaid, in the United States mail. All invoices must be approved by the Contract Manager.

b. The invoice shall contain the following information:

(1) The word "INVOICE" should appear in a prominent location at the top of the page(s);

(2) Printed name of the Contractor/Agency;

(3) Business address of the Contractor/Agency, including P.O. Box, City, State, and Zip Code;

(4) Name of State Water Board/Regional Water Board being billed;

(5) The date of the invoice;

(6) The number of the agreement upon which the claim is based; and

(7) An itemized account of the services for which the State Water Board is being billed:

(a) The time period covered by the invoice, i.e., the term "from" and "to";

(b) A brief description of the services performed;

(c) The method of computing the amount due. On cost reimbursable agreements, invoices must be itemized based on the categories in the Budget attached as a part of the agreement. The amount claimed for salaries/wages/consultant fees must also be explained; i.e., hours or days worked times the hourly or daily rate = the total amount claimed;

(d) The total amount due; this should be in a prominent location in the lower right-hand portion of the last page and clearly distinguished from other figures or computations appearing on the invoice; the total amount due shall include all costs incurred by the Contractor under the terms of this agreement; and

(e) Original signature of Contractor/claimant (not required of established firms or entities using preprinted letterhead invoices).

7. Project Officials:

a. The State Water Board's Contract Manager shall be Patrick Morris of the Central Valley Regional Board. The Contract Manager shall be the day-to-day representative for administration of this agreement, and, except as otherwise specifically provided, shall have full authority to act on behalf of the State Water Board with respect to this agreement. The State Water Board's Executive Director, or designee, may also perform any and all acts which could be performed by the Contract Manager under this agreement. Except as otherwise expressly provided, all communications relative to this agreement shall be given to the Contract Manager.

b. The Contractor's Project Director shall be Koll Buer. The Project Director shall be the Contractor's representative for the technical conduct of the agreement and shall have full authority to act on behalf of the Contractor. All communications given to the Project Director shall be as binding as if given to the Contractor. The Contractor's Administrative Representative shall be Barbara Polson. The Administrative Representative shall be the Contractor's representative for the administration of this agreement.

c. The parties may change their Contract Manager or Project Director upon providing ten (10) days written notice to the other party.

8. Commencement of Work; Delays Beyond Control of Contractor:

a. Upon receipt of an executed original or duplicate original of the agreement, which has been approved by the State Department of General Services if required, the Contractor shall commence work as specified in Exhibit B, except that the Contractor shall not proceed with any work or portion thereof for which a notice to proceed must be received by the Contractor until such notice has been received.

b. Delay in completion of work or delivery of materials or services by the Contractor within the time or times specified in this agreement which arise from causes beyond the control of the Contractor and without fault or negligence on the part of the Contractor shall entitle the Contractor to a reasonable extension of time for performance but no additional compensation. Causes beyond the control of the Contractor shall be deemed to include, but are not necessarily limited to, unusually severe weather, acts of God, acts of the public enemy, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, and delays of suppliers or approved subcontractors arising from causes beyond the control and without fault or negligence of both the Contractor and such suppliers or approved subcontractors. Delay under this paragraph shall entitle the Contractor to an extension of time only if the Contractor, within ten (10) days of occurrence of any circumstance which will or may cause delay, notifies the Contract Manager, in writing, of the anticipated delay and the reasons therefore.

9. Contract Modifications:

The State Water Board may, at any time, without notice to any sureties, by written order designated or indicated to be a "contract modification", make any change in the work to be performed under this agreement so long as the modified work is within the general scope of work called for by this agreement, including but not limited to changes in the specifications or in the method, manner, or time of performance of work. If the Contractor intends to dispute the change, the Contractor must, within ten (10) days after receipt of a written "contract modification", submit to the State Water Board a written statement setting forth the disagreement with the change.

10. Termination:

a. The State Water Board may terminate performance of work under this agreement upon 30 days written notice.

b. Any termination shall be effected by written notice to the Contractor, either hand-delivered to the Contractor or sent certified mail, return receipt requested. The notice of termination shall specify the effective date of termination.

c. Upon receipt of notice of termination, and except as otherwise directed in the notice, the Contractor shall:

(1) Stop work on the date specified in the notice;

(2) Place no further orders or enter into any further subcontracts for materials, services or facilities except as necessary to complete work under the agreement up to effective date of termination.

(3) Terminate all orders and subcontracts;

(4) Promptly take all other reasonable and feasible steps to minimize any additional cost, loss, or expenditure associated with work terminated, including, but not limited to reasonable settlement of all outstanding liability and claims arising out of termination of orders and subcontracts;

(5) Deliver or make available to the State Water Board all data, drawings, specifications, reports, estimates, summaries, and such other information and material as may have been accumulated by the Contractor under this agreement, whether completed, partially completed, or in progress.

d. In the event of termination, an equitable adjustment in the price provided for in this agreement shall be made. Such adjustment shall include reasonable compensation for all services rendered, materials supplied, and expenses incurred pursuant to this agreement prior to the effective date of termination.

11. Amendment:

This agreement may be amended upon written mutual agreement. Amendments which require approval by the State Department of General Services shall be effective only upon receipt of such approval.

12. Budget Flexibility:

Subject to the prior review and approval of the contract manager, line item shifts of up to $25,000 or ten percent of the annual contract total, whichever is less, may be made up to a cumulative maximum of $50,000 per fiscal year. Line item shifts may be proposed/requested by either the State Water Board or the Contractor in writing and must not increase or decrease the total contract amount allocated per fiscal year.

EXHIBIT A - GENERAL PROVISIONS

A. Disputes:

1. Except as otherwise provided in this agreement, any dispute arising under or relating to the terms of this agreement, or related to performance hereunder, which is not disposed of by agreement shall be decided by the Contract Manager, who shall reduce such decision to writing and mail or otherwise furnish a copy thereof to the Contractor. The decision of the Contract Manager shall be final and conclusive unless, within fifteen (15) calendar days from the date of receipt of such copy, the Contractor mails or otherwise delivers a written appeal to the State Water Board's Executive Director. The decision of the State Water Board's Executive Director, or authorized representative, on such appeal shall be final and conclusive unless determined by a court of competent jurisdiction to have been fraudulent, or capricious, or arbitrary, or so grossly erroneous as necessarily to imply bad faith, or not supported by any substantial evidence. In connection with any appeal under this clause, the Contractor shall be afforded an opportunity to be heard and to offer evidence and argument in support of the appeal. Pending final decision on any dispute hereunder, the Contractor shall proceed diligently with the performance of the agreement work as directed by the Contract Manager unless the Contractor has received notice of termination. Decisions on any disputes hereunder may include decisions of both fact and law; provided, however, that nothing herein shall be construed as making final any decision on a question of law in the event of any subsequent legal proceeding before a court of competent jurisdiction.

2. Authority to terminate performance under the terms of this agreement is not subject to appeal under this Section. All other issues including, but not limited to, the amount of any equitable adjustment, and the amount of any compensation or reimbursement which should be paid to the Contractor shall be subject to the disputes process under this Section.

B. Rights in Data:

The Contractor agrees that all data, plans, drawings, specifications, reports, computer programs, operating manuals, notes, and other written or graphic work produced in the performance of this agreement are subject to the rights of the State Water Board as set forth in this section. The State Water Board shall have the right to reproduce, publish, and use all such work, or any part thereof, in any manner and for any purposes whatsoever and to authorize others to do so. If any such work is copyrightable, the Contractor may copyright the same, except that, as to any work which is copyrighted by the Contractor, the State Water Board reserves a royalty-free, nonexclusive, and irrevocable license to reproduce, publish, and use such work, or any part thereof, and to authorize others to do so.

C. Property Acquisitions:

1. Property, as used in this section, shall include:

   a. Equipment - Tangible property (including furniture) with a unit cost of $500.00 or more and a useful life of four (4) years or more. Actual cost includes the purchase price plus all costs to acquire, install and prepare the equipment for its intended use.

   b. Furniture - Standard office furnishings including desks, chairs, bookcases, credenzas, tables, coat racks, etc.

   c. Portable Assets - Items considered "highly desirable" because of their portability and value; e.g., calculators, typewriters, dictaphones, cameras and microscopes.

   d. Electronic Data Processing (EDP) Equipment - All computerized and auxiliary automated information handling including system design and analysis, conversion of data, computer programming, information storage and retrieval, voice, video and data communications, requisite system controls, simulation and all related interactions between people and machines.

2. No property shall be purchased by the Contractor with funds provided under this agreement.

D. Income Restrictions:

The Contractor agrees that any refunds, rebates, credits, or other amounts (including any interest thereon) accruing to or received by the Contractor under this agreement shall be paid by the Contractor to the State Water Board, to the extent that they are properly allocable to costs for which the Contractor has been reimbursed by the State Water Board under this agreement.

E. Disclosure Requirements:

1. Any document or written report prepared in whole or in part pursuant to this agreement shall contain a disclosure statement indicating that the document or written report was prepared through agreement with the State Water Board. The disclosure statement shall include the agreement number and dollar amount of all agreements and subcontracts relating to the preparation of such documents or written reports. The disclosure statement shall be contained in a separate section of the document or written report.

2. If the Contractor or subcontractor(s) are required to prepare multiple documents or written reports, the disclosure statement may also contain a statement indicating that the total agreement amount represents compensation for multiple documents or written reports.

3. Any documents which are published by the Contractor shall contain the following statement:

   This project has been funded wholly or in part by the United States Department of Energy Assistance Agreement No. 1432 CO250003 to the State Water Resources Control Board and by Contract No.6-068-150-0 in the amount of $40,000.00. The contents of this document do not necessarily reflect the views and policies of the Department of Energy or the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

4. The Contractor shall include in each of its subcontracts for work under this agreement a provision which incorporates the requirements stated within this Section.

F. Permits, Subcontracting, Waiver, Remedies and Debarment:

1. The Contractor shall procure all permits and licenses necessary to accomplish the work contemplated in this agreement, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work.

2. Any subcontractors, outside associates, or consultants required by the Contractor in connection with the services covered by this agreement shall be limited to such individuals or firms as were specifically identified and agreed to during negotiations for this agreement, or as are specifically authorized by the Contract Manager during the performance of this agreement. Any substitutions in, or additions to, such subcontractors, associates, or consultants, shall be subject to the prior written approval of the Contract Manager.

3. Any waiver of rights with respect to a default or other matter arising under the agreement at any time by either party shall not be considered a waiver of rights with respect to any other default or matter.

4. Any rights and remedies of the State Water Board provided for in this agreement are in addition to any other rights and remedies provided by law.

5. Contractor shall not subcontract with any party who is debarred or suspended or otherwise excluded from or ineligible for participation in federal assistance programs under Executive Order 12549, "Debarment and Suspension". For federally funded agreements, Contractor shall not subcontract with any individual or organization on EPA's List of Violating Facilities.

G. Travel and Per Diem:

Any reimbursement for necessary traveling and per diem shall be at rates not to exceed those amounts paid to the State's represented employees under collective bargaining agreements currently in effect. No travel outside the State of California shall be reimbursed unless prior written authorization is obtained from the State.

ATTACHMENT ONE TO EXHIBIT A

FEDERAL PROVISIONS

A. Privity:

This agreement is funded in whole or in part by a grant from the United States Department of Energy (DOE). Neither the United States nor any of its departments, agencies, or employees is, or will be, a party to this agreement or any lower tier subcontract nor to any solicitation or request for proposal.

B. Compliance with Federal Regulations:

The Contractor understands that the State Water Board is obligated, in accordance with its assistance agreement with the DOE to comply with the provisions of federal regulations contained in Title 40 CFR and any conditions in the grant agreement and any amendments thereto. In order to ensure that the State Water Board can meet these obligations, the Contractor warrants, represents, and agrees that it and its subcontractors, employees, and representatives will comply with (1) all applicable provisions of Title 40 CFR and (2) all general and special conditions contained in the DOE/State Water Board Assistance Agreement No. 1432 CO250003 and any amendments thereto.

C. Copyrights:

The Contractor agrees to and does hereby grant to the DOE a royalty-free, nonexclusive and irrevocable license to reproduce, publish or otherwise use, and to authorize others to use, for Federal Government purposes:

1. The copyright in any work developed under this agreement; and

2. Any rights of copyright which the Contractor purchases, in whole or in part, with funds provided by this agreement.

D. Standards for Financial Management System:

The Contractor and all subcontractors shall maintain fiscal control and accounting procedures which are sufficient to:

1. Permit preparation of reports required by 40 CFR Part 31 (including those required by 40 CFR Part 31.40 and 31.41) and statutes authorizing the grant.

2. Permit tracing of funds to a level of expenditures adequate to establish that such funds have not been used in violation of the restrictions and prohibitions of applicable statutes.

A requirement to this effect shall be placed in all subcontracts related to performance of work under this agreement.

E. Allowable Costs:

1. Applicable Cost Principles

The cost principles for this agreement are applicable as set forth below:
OMB Circular A-87 for State, local or Indian tribal governments,
OMB Circular A-122 for Private nonprofit organizations,
OMB Circular A-21 for Educational Institutions, or
48 CFR Part 31 for For-profit organizations.

2. Limitation on Consultant Fees

Funds provided under this agreement shall not be used for payment of salaries to individual consultants retained by the Contractor or any subcontractors in excess of the rate for Level 4, Federal Executive Schedule. The limit expressed herein does not include transportation and subsistence costs for necessary travel for work required under this agreement.

F. Contingent Funding:

1. It is mutually understood between the parties that this agreement may have been written before ascertaining the availability of congressional appropriation of funds, for the mutual benefit of both parties in order to avoid program and fiscal delays which would occur if the agreement were executed after that determination was made.

2. This agreement is valid and enforceable only if sufficient funds are made available to the State by the United States Government for the fiscal year(s) covered by this agreement for the purposes of this program. In addition, this agreement is subject to any additional restrictions, limitations, or conditions enacted by the Congress or any statute enacted by the Congress which may affect the provisions, terms, or funding of this agreement in any manner.

3. It is mutually agreed that if the Congress does not appropriate sufficient funds for the agreement, the agreement shall be amended to reflect any reduction in funds.

4. The State Water Board has the option to terminate the agreement under the termination clause or to amend the agreement to reflect any reduction of funds.

G. Recycled Paper

Contractor agrees to use recycled paper for all reports which are prepared as a part of this agreement and delivered to the State Water Board. This requirement does not apply to reports which are prepared on forms supplied by the DOE. This requirement applies even when the cost of recycled paper is higher than that of virgin paper.

H. Single Audit Act:

To the extent applicable, the Contractor shall be subject to and shall comply with the provisions and requirements of the Single Audit Act of 1984 (Pub. L. 98-502) and implementing policies, procedures and guidelines, including applicable circulars issued by the Federal Office of Management and Budget.

EXHIBIT B - SCOPE OF WORK

A. Scope and Objectives:

LOCATION

The Walker Mine is an inactive copper mine located approximately 20 miles east of Quincy and 24 miles north of Portola in Plumas County. Access is by County Road 112, through the Plumas National Forest from either California Highway 70 on the south or Taylorsville/Genesse Valley on the north. County Road 112 is a well-graveled road of which approximately 12 miles are paved from Portola toward the mine site.

The Walker Mine main 700 level portal is at an elevation of approximately 6200 feet. Dirt roads near the site are closed throughout most of the late fall, winter and early spring due to heavy snowfall.

The State Water Board and its agents have right of access to the Walker Mine as a result of a court ordered judgment against Calicopia Corporation, owners of the patented lands of Walker Mine.

RESPONSIBILITY

The Agency will construct a ground water monitoring well. The well will extend about 1000 feet to intersect mine workings at the same elevation as the mine seal. These activities are not related to active mining and/or mining operations by the State or the mine owner. The Walker Mine site has been abandoned and there are no mining operations.

The Agency is responsible for all work required to locate and install the monitoring well. The Regional Board will approve the monitoring well location prior to any drilling activities. It is understood that the Agency will hire a licensed drilling contractor to complete well construction activities.

METHOD

The project consists of locating and constructing a ground water monitoring well by the Agency. The work consists of (1) determining the location of the monitoring well to intersect mine workings behind the concrete seal, (2) designing a monitoring well, (3) drilling of a borehole, and (4) installation of the monitoring well.

The Agency will be responsible for determining the actual location of the monitoring well. The Agency will review historic mine maps and survey data to determine the actual target location for the monitoring well. Mine maps with location of the mines survey control is critical to the placement of the well location. Regional Board records and reports on prior adit mappings and construction activities are available for review by the Agency.

The field work consists of moving drilling equipment onto the monitoring well location, drilling one 8-inch borehole up to 1000 feet deep, and logging the borehole during drilling. The borehole will be drilled using an air rotary drilling system. Through surveying, the Agency will determine if the target stope has been intersected. The Agency will measure the borehole drift through the use of instruments such as a downhole inclinometer. If the target stope is not intersected then, the Regional Board and the Agency will meet to determine if the existing borehole can be redirected and redrilled or if another borehole should be attempted based on available information. Otherwise, the Regional Board may terminate this Interagency Agreement.

A monitoring well will then be constructed in the borehole using stainless steel casing and screen. No development would be necessary for this well as there will be no sand pack around the well screen.

The preferred drilling method is using an air rotary drilling system, using either a hammer or tricone bit. A mud rotary drill system is not recommended because the mud would be lost to fractures when the drill pipe approached the mine workings and may influence the chemistry of the mine waters. An air hammer drilling system would be faster than mud rotary and would not affect the surrounding environment.

There is concern about drift of the borehole while drilling. Deflections of the bit while drilling can seriously affect the location of the bottom of the borehole. The attitude of the bedding and foliation at the Walker mine will likely cause the borehole to drift. An acceptable accuracy is 3 in/100ft. Down hole directional equipment may be necessary to evaluate the drift in the borehole while drilling. Directional drilling may be needed to correct excessive drift.

A 4.5-inch outside diameter stainless steel well casing and well screen will be used for the entire well. The U.S. Department of Energy provided the well casing; the casing is presently at a Caltrans facility in Beckwourth CA, approximately 20 miles from Walker Mine.

B. Work to be Performed:

The Contractor shall be responsible for the performance of the work as set forth hereinbelow and for the preparation of products and a final report as specified in this Exhibit. The Project Director shall promptly notify the Contract Manager of events or proposed changes which could affect the scope, budget or schedule of work performed under this agreement.

Task 1: General Requirements

1.1 The Agency shall manage the site preparation, borehole drilling, monitoring well installation, and site reclamation.

1.2 The Agency shall require the well drilling Construction Contractor to possess a valid C-57 California State Water Well Contractors License and shall provide the license number and expiration date, and a copy of the $1,000,000.00 liability insurance certificate.

1.3 The Agency shall provide a California registered geologist or an appropriately qualified individual under the direct supervision of a California registered geologist on-site during drilling, construction, and completion of the monitoring well.

1.4 The Agency shall complete all monitoring well construction activities, site reclamation, and construction demobilization prior to October 1, 1997. The Agency shall submit a tentative construction and demobilization schedule to the Regional Board prior to the initiation of construction.

1.5 The Agency shall provide all monitoring well construction services for the tasks described below under the direction and supervision of a registered geologist. All work at the well site, including maintenance and repair of equipment, shall be done by the Construction Contractor only when the geologist or a qualified representative is present, or unless approved by the geologist in advance of the work.

1.6 The Agency shall be responsible for mobilization of all equipment and materials to the project site and for acquisition of all permits required for the completion of the tasks associated with the monitoring well installation as set forth in this Scope of Work. The Agency shall comply with all terms and conditions of all permits by state, county, and local agencies.

1.7 The Agency shall be responsible for loading, transporting, and unloading the stainless steel casing and well screen from a Caltrans facility in Beckwourth CA to the monitoring well site.

1.8 The Agency shall be responsible for electrical power and water supply throughout the construction period. The Construction Contractor shall provide all materials required (such as centralizers, grout, etc.) to install a functional monitoring well. The Regional Board will furnish the 4.5-inch outside diameter stainless steel well casing and screen.

1.9 The Regional Board and/or the Agency have the right to terminate this Interagency Agreement for unforseeable circumstances and expenses including, but not limited to, 1) the lack of or the inability to locate field reference points/monuments during the initial well location survey, 2) substantial inaccuracies/deviations between the initial control survey and existing Walker Mine maps, 3) excessive drift during drilling that, due to local geology, cannot be corrected, 4) missing the target stope during drilling based on the accuracy of the available maps, cross-sections, and information on Walker Mine, or, 5) inaccessibility of drilling site due to topography or impracticality of road and pad construction.

1.10 The Agency shall measure the borehole drift through the use of instruments such as a downhole inclinometer as the borehole is being drilled. If the target stope is not intersected on the initial borehole, the Regional Board and the Agency shall meet to determine if the existing borehole can be redirected and redrilled or if another borehole should be attempted based on available information. Otherwise, the Regional Board has the right to terminate this Interagency Agreement.

1.11 All work shall be done in strict accordance with applicable industrial safety and Cal/OSHA regulations. The Agency shall submit a site-specific Injury and Illness Prevention Plan as required by Cal/OSHA prior to mobilization. Throughout the construction project, the Agency shall conduct daily safety tailgate meetings.

Task 2 Determination of Monitoring Well Location

2.1 The Agency shall determine the location and depth of the monitoring well. The Agency shall drill the well about one mile north of the 700 level portal near the main shaft into the Central Ore Body. The well shall intersect a void in the mine workings between 1000 and 3000 feet behind the seal at the 700 level. The mine seal is approximately 2675 feet from the portal. The well shall extend from ground surface up to 1000 feet below ground surface.

2.2 The Agency shall review historic mine maps and survey data to locate voids, shafts, and stopes along the 700 Level. The Agency may use information, data, and maps that are available at the Regional Board in determining the location of the well. Regional Board staff will make all Walker Mine maps, data, and reports in their possession available to the Agency. The Agency shall be responsible for obtaining any other required information from outside sources, including additional surveyed maps of the mine workings. This includes but is not limited to information from other agencies. The information required to determine the monitoring well location includes but is not limited to mine stope size, access on the surface, connection with the target workings behind the seal, depth of well, depth of water table, and maximum water level expected in mine.

2.3 The Agency shall meet with Regional Board staff to discuss possible targets at the 700 level.

2.4 The Agency shall prepare and submit to Regional Board staff a report containing all calculations and maps used to determine the location of the well, the target stope, and the depth of the well prior to site preparation work. Regional Board staff will review and approve the well location report.

2.5 The Agency shall determine if it is necessary to access other than the Walker Mine property for the well construction. The Regional Board will obtain any necessary permission from landowners or from any other agencies holding any property interest in the site so that site surveying and well installation may proceed. If for any reason it becomes impracticable to proceed at the selected site, Regional Board staff and Agency may mutually select an alternative site.

TASK 3: Monitoring Well Design:

3.1 The Agency shall review the site geology in order to advise the Construction Contractor on well drilling requirements dictated by the geology.

3.2 The Agency shall prepare and submit to Regional Board staff for approval a preliminary monitoring well design based on the results of the Agency's monitoring well location investigation. The Agency shall determine which drilling technique (either standard drilling methods or directional drilling) would be most appropriate for the borehole construction. The monitoring well shall be constructed with 4.5-inch diameter stainless steel well casing (type 316,NPT) and stainless steel screen provided by the Regional Board.

Task 4: Field Survey for Well Location

4.1 After the Agency determines the well location and depth, the Agency shall survey the site of the borehole on the surface over the target stope based on findings in the well location report. The Agency shall be responsible for locating survey reference markers.

4.2 After the borehole is drilled and the well is completed, the Agency shall perform another survey to obtain well location and elevation data.

Task 5: Site Preparation

5.1 The Agency may need to construct a road to access the drilling site and construct a drilling pad. This may consist of repairing existing roads, construction of a road to the drilling site, and construction of a level drill pad of sufficient size to accommodate drilling equipment. Road and drill pad placement may involve tree cutting. Where possible the Agency must limit disturbance.

Task 6: Monitoring Well Construction

6.1 The Agency shall select and award a contract to a qualified Construction Contractor for the drilling and well construction activities. The driller shall furnish one complete drilling outfit equipped with drilling tools and accessory equipment including but not limited to a truck-mounted air rotary drill rig in good working condition. The drill rig, tools, and equipment shall be capable of drilling a 8-inch diameter minimum size hole to a depth of up to 1000 feet.

6.2 The Agency's Construction Contractor shall minimize the risk of contaminating the borehole and mine water with the use of an oil-less compressor and filtration of the compressor air at the drill rig.

6.3 The Agency shall oversee the drilling of a borehole with a minimum diameter of 8-inches up to a maximum depth of 1000 feet. The Agency shall log the geology of the borehole. The Agency shall measure the borehole drift through the use of instruments such as a downhole inclinometer. The Agency shall determine when the target stope has been intersected. The Agency shall confirm the location of the end of the borehole and report the results to the Regional Board prior to additional drilling or installation of the well casing. After sufficient evidence indicates the target stope is intersected, the borehole shall be completed as a monitoring well.

6.4 The Agency shall oversee the disposal of the drill cuttings materials in appropriate on-site stockpiles or off-site disposal sites approved by Regional Board staff.

6.5 The Agency shall determine the height of the intersected stope.

6.6 The Agency shall be responsible for overseeing the installation of stainless steel casing in the borehole. The well casing shall be 4.5-inch O.D. NPT (type 316, schedule 10). The casing shall be installed from the well screen to the ground surface. All stainless steel casing joints shall be flush-threaded to adjoining segments.

6.7 The Agency shall be responsible for overseeing the installation of a stainless steel well screen at the end of the well casing. The length of the screen will be determined in the field. The well screen shall not be in contact with the floor of the stope. The Agency shall provide and install a non-perforated stainless steel cap on the lower end of the screen. No filter pack is required for this monitoring well

6.8 The Agency shall be responsible for overseeing the grouting of the annulus between the formation and the casing with a grout compatible with the casing and the formation. Grout shrinkage shall be minimized. Grout shall not be placed within 50 feet from the open stope. The annular sealant shall be provided to comply with DWR standards. The Agency shall determine the volume of grout required to seal the annular space and record the volume of grout used.

6.9 The Agency shall be responsible for overseeing the installation of a surface seal on top of the grout seal. The Agency shall design the surface seal such that the well is protected from damage due to frost heave. The surface seal shall be composed of neat cement or concrete. The surface seal shall form at least a two-foot wide, four-inch thick apron at ground surface, constructed with a slope to drain water away from the well casing. The agency shall provide and install a flush-to-ground protection structure with a lockable watertight cover around the well casing. The Agency shall anchor the cover into the surface seal. After surveying the completed well, the location of the well shall be camouflaged so as to minimize vandalism.

6.10 The Agency shall determine the depth to water within the well. The Agency shall purge a minimum of three well volumes from the well and then collect a two gallon sample for water quality analysis. Regional Board staff will be present during the sampling event and will be responsible for the water quality analysis.

Task 7: Site Reclamation

7.1 The Agency shall be responsible for overseeing the reclamation of the drilling pad and access road from the main road to the drilling pad. The reclamation shall include topsoil replacement and reseeding. All reclamation work shall be done to the satisfaction of Regional Board staff prior to completion of demobilization.

Task 8: Final Report

8.1 The Agency shall submit a final report to the contract manager at the completion of the well installation. This report shall detail the construction features and the methods used for the monitoring well installation. This report shall include the final survey data, geologic drill logs, water elevation data and a figure showing well construction features.

The final report shall include a complete breakdown of all billable items for the Agency and the Construction Contractor (driller) to include labor costs, survey costs, equipment rental costs, material costs, administrative and overhead costs, site preparation and reclamation costs, and mobilization/demobilization costs.

C. SCHEDULE OF COMPLETION DATES

Task	Description	Completion Date
1.11	Injury and Illness Prevention Plan	June 1, 1997
1.4	Complete Construction Activities	October 1, 1997
2.4	Well Location Report	July 1, 1997
3.2	Well Design Report	July 1, 1997
8.0	Final Report	November 1, 1997

EXHIBIT C - BUDGET
WALKER MINE
PLUMAS COUNTY

MONITORING WELL CONSTRUCTION BUDGET

Surveying		$4,500
Project management/geology		13,000
Drilling		$52,160
	Subtotal	$69,660
	20% Contingency	$13,932
	Total	$83,592

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO.

CLEANUP AND ABATEMENT ORDER NO. 97-715
FOR
CEDAR POINT PROPERTIES, INC.
WALKER MINE
PLUMAS COUNTY

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Board) find that:

1. Cedar Point Properties, Inc. (hereafter referred to as Discharger) owns the Walker Mine property. The Walker Mine is in central Plumas County about 24 miles north of Portola in Sections 19, 29, 30, 31, and 32, T25N, R12E, and in Sections 5,6,7, and 8, T24N, R12E, MDB&M. The property consists of Assessor's Parcel Numbers 009-080-01, 009-090-01, and 009-100-09.

2. The Walker Mine is a 782-acre inactive copper mine. The Discharger proposes to harvest the timber from the property.

3. There are three discharges from the Walker Mine property. These are identified as discharges from the main 700 level adit (portal), intermittent discharge from an unlined settling pond, and intermittent discharges of surface water runoff from waste piles. The Discharger is aware of the discharges from the property, and has the ability to control those discharges.

4. Walker Mine has impacted waters in the Little Grizzly Creek watershed, causing a condition of pollution and nuisance. Acid mine drainage from the mine portal, settling pond, and waste piles flows directly to Dolly Creek, then to Little Grizzly Creek. Little Grizzly Creek flows into Indian Creek which flows into the North Fork Feather River.

5. The Water Quality Control Plan (third addition) lists Little Grizzly Creek as a water quality limited segment. Beneficial uses of surface water are aquatic life, wildlife habitat, and recreation.

6. Since the Walker Mine closure in 1941, the site has discharged acid and heavy metals directly into Dolly Creek. In November 1987, the Regional Board installed an engineered concrete mine seal 2,675 feet underground from the mine portal. The seal installation prevented direct discharge of acid mine drainage from the underground ore zone to the surface waters of Dolly Creek. Discharges from the settling pond and the waste piles have not yet been abated.

7. Since the 1980's, the Board has maintained the mine seal and other remedial structures at Walker Mine. Safe access to the mine seal is required to monitor its condition and water pressure, and monitor the effectiveness of the seal in preventing surface water pollution. The access tunnel to the seal must be maintained and the performance of the seal must be continually monitored for effectiveness, leakage, and hydrostatic pressure.

8. In June 1997, the Board adopted Operation and Maintenance Procedures to maintain the mine seal and surface water diversion structures at the Walker Mine. The procedures provide details on specific activities that are required to maintain the

Walker Mine remedial structures. The maintenance program addresses safe mine entry, mine seal accessibility and integrity, surface water quality monitoring, surface water erosion, and vandalism. The maintenance program requires Board staff to conduct periodic site inspections, monitor water quality, identify problems, and contract for repair and replacement of site structures. The Discharger has received a copy of the Operation and Maintenance Procedures.

9. The Board has submitted to the State Water Resources Control Board for approval a Remediation Plan (pursuant to Water Code sections 13397 and 13398) for the Walker Mine Acid Mine Drainage Abatement Project. The plan provides for long term operations and maintenance of existing remedial activities. This plan includes an identification of the Walker Mine site, description of the affected waters of the state, a description of the existing remediation project and proposed actions to improve the project, and a plan for monitoring remedial activities. The Discharger has received a copy of the Remediation Plan.

10. Section 13304 of the California Water Code states in part that "(a) Any person who has discharged or discharges waste into the waters of this state in violation of any waste discharge requirement or other order or prohibition issued by a regional board or the state board, or who has caused or permitted, causes or permits, or threatens to cause or permit any waste to be discharged or deposited where it is, or probably will be, discharged into the waters of the state and creates, or threatens to create, a condition of pollution or nuisance, shall upon order of the regional board, clean up the waste or abate the effects of the waste, or, in the case of threatened pollution or nuisance, take other necessary remedial action, including, but not limited to, overseeing cleanup and abatement efforts. Upon failure of any person to comply with the cleanup or abatement order, the Attorney General, at the request of the board, shall petition the superior court for that county for the issuance of an injunction requiring the person to comply with the order. In any such suit, the court shall have jurisdiction to grant a prohibitory or mandatory injunction, either preliminary or permanent, as the facts may warrant."

11. Section 13267 of the California Water Code states in part that "In conducting an investigation specified in subdivision (a), the regional board may require that any person who has discharged, discharges, or is suspected of discharging, or who proposes to discharge waste within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of discharging, or who proposes to discharge, waste outside of its region that could affect the quality of waters within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the regional board requires. The burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the reports."

12. Section 13304(c)(1) of the California Water Code states that: "... the person or persons who discharged the waste, discharges the waste, or threatened to cause or permit the discharge of the waste within the meaning of subdivision (a), are liable to that government agency to the extent of the reasonable costs actually incurred in cleaning up the waste, abating the effects of the waste, supervising cleanup or abatement activities, or taking other remedial actions..."

13. The issuance of this Order is an enforcement action taken by a regulatory agency and is exempt from the provisions of the California Environmental Quality Act, pursuant to Section 15321(a)(2), Title 14, California Code of Regulations.

14. Any person affected by this action of the Board may petition the State Water Resources Control Board to review the action. The petition must be received by the State Board within 30 days of the date on which the Board took action. Copies of the law and regulations applicable to filing petitions will be provided upon request.

IT IS HEREBY ORDERED that pursuant to Sections 13267 and 13304 of the California Water Code, Cedar Point Properties, Inc., shall:

1. Prevent additional releases of waste to surface waters.

2. Provide continuous operations and maintenance of existing remedial structures as prescribed in the June 1997 Operations and Maintenance Procedures and the Remediation Plan, or implement an alternative plan that will achieve this requirement.

3. Complete tasks in compliance with the time schedule:

Task	Compliance Date
Submit a completed application for an NPDES permit	**1 February 1998**
Provide a technical report on how the Discharger proposes to comply with item 2	**1 April 1998**
Provide a technical report with time schedule on how the Discharger proposes to use best management practices to minimize waste discharges from tailings near the mine portal	**1 July 1998**
Implement best management practices for mine tailings and settling pond	**1 October 1998**

4. Reimburse the Regional Water Quality Control Board for reasonable costs associated with oversight and remedial activities at this facility. Failure to do so shall be considered a violation of this Order.

5. Grant reasonable site access to the Regional Board and its agents.

6. Design and implement surface water diversions which minimize the surface water runoff into the mine workings at the subsidence areas by **1 July 1999.**

7. Continue to sample and analyze surface water in the Little Grizzly, Ward, and Nye Creek watersheds in accordance with the Operations and Maintenance Procedures in order to monitor the project's success in preventing additional pollution. The Discharger shall submit semi-annual reports of the results of monitoring.

8. Any remediation or monitoring activities shall be continued until such time as the Board determines that sufficient cleanup has been accomplished and this Order has been rescinded.

This Order is effective upon the date of signature.

GARY M. CARLTON, Executive Officer

7 Oct 1997
Date

October 1997

PWM

William J. Deutsch

GROUNDWATER GEOCHEMISTRY

Fundamentals and Applications to Contamination

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DEDICATION

For Marie Pavish
Elizabeth, Emily, and Annika

immobilization of groundwater contaminants can also occur under reducing conditions. The following overall reaction has been shown to occur in lake sediment with reactive organic matter:[10-12]

$$4Fe(OH)_3 + 4SO_4^{2-} + 9CH_2O \rightarrow 4FeS + 8HCO_3^- + 11H_2O + CO_2 \qquad (12\text{-}15)$$

In this reaction iron and sulfate are reduced by the organic matter CH_2O and precipitated as the iron monosulfide FeS. The reaction is catalyzed by sulfate-reducing bacteria. The generation of bicarbonate provides acid-neutralizing capacity to the system. This neutralization mechanism will only be permanent if the FeS is not allowed to oxidize in the future, such as by burial in lake sediments. This neutralization may also occur in an aquifer environment where the acidic plume contacts a zone of reactive organic matter that has sufficient reducing capacity to lower the Eh to the stability field of the sulfide minerals (Figure 12-1).

In summary, the most common reactive neutralizing agents in surface water or groundwater systems are dissolved bicarbonate and carbonate; however, the neutralizing capacity of this source is very limited. Carbonate minerals present in the system provide the next most reactive phase, and their neutralizing capacity is a function of their concentration and availability to the acidic solution. Rapid precipitation of ferrihydrite on neutralization by carbonate minerals may coat the carbonate solids, reducing their reactivity, or may coat the sulfide minerals, making them less susceptible to continued oxidation.[7] If neither dissolved or solid inorganic carbon is present in the system, then organic acids may provide some limited neutralizing capacity proportional to their dissolved concentration. As the pH of the system decreases, cation exchange, as well as the dissolution of clay minerals, may consume acidity. Under reducing conditions, bacterial sulfate reduction can provide alkalinity to the system by the generation of bicarbonate. Residual neutralizing capacity will be provided by the primary silicate and aluminosilicate minerals, but these reactions are slow on the time frame of typical groundwater residence and are not expected to be rapid neutralizers of acidic solutions. These general acid-neutralizing reactions are not limited to the example of pyrite oxidation. Any acidic source will tend to be neutralized by one or more of these mechanisms.

12.2. ACIDIC ENVIRONMENTS

Sulfide mineral oxidation and the production of acidic conditions, as described above, occur in a variety of man-made environments and in certain unpeiturbed systems. Acidic conditions created by human activities include acid mine drainage; storage piles of ore, waste rock, and tailings; and lakes associated with excavation of ore deposits. The characteristics of man-made and naturally acidic environments are described in this section.

Naturally Acidic Conditions

The natural occurrence of highly acidic conditions due to, for example, pyrite oxidation is somewhat rare because the rate of acid generation can be balanced by neutralization reactions. Water and oxygen in the unsaturated zone will oxidize pyrite, but the solution may in turn be neutralized as it flows through the unsaturated and saturated zones on its

naturally weathers and slowly exposes new sulfide minerals to oxidizing conditions. Mechanical weathering such as mass wasting, which is primarily important in areas of high relief, may rapidly expose acid-producing minerals to earth surface conditions. In these cases localized zones of acidity may be created and surface waters may be acidic because of the relatively limited opportunities for neutralization by water/rock interactions. The Summitville (Colorado) area contains a number of drainages that appear to have been impacted by acid conditions produced by the natural process of sulfide mineral weathering.[13,14]

Acid Mine Drainage

One of the most common occurrences of acidic conditions is associated with the mining of coal and base or precious metals. Pyrite occurs with the ore material because the environment in which the coal or metals were deposited is reducing and is conducive to the formation of pyrite and other sulfide minerals along with the ore. Mining operations expose sulfide minerals in the host rock to atmospheric oxygen either in the underground workings or in surface spoils. In the case of coal deposits, pyrite is a minor component of the organic ore material; however, for metal deposits, pyrite may be present at high concentrations relative to the metal being extracted. In either case it does not require large amounts of pyrite to create highly acidic conditions.

The occurrence of acid mine drainage in the copper-zinc West Shasta Mining District of northern California has been extensively studied because of its impact on nearby surface water. Nordstrom et al.[15] characterized mine effluent and its effect on Boulder Creek and downstream Spring Creek. They measured pH values as low as 1.1 in the mine effluent with the pH in the creeks increasing to 2.9 over a distance of 14 km from the point of effluent discharge. Iron and sulfate concentrations exceeded 10,000 and 60,000 mg/L, respectively, in the effluent and decreased downstream to less than 1000 mg/L due to dilution and probable precipitation of iron and sulfate minerals, such as ferrihydrite ($Fe[OH]_3$) and jarosite ($KFe_3[SO_4]_2[OH]_6$). Along the surface water flowpath, aluminum concentrations decrease from 1400 to 47 mg/L, partially due perhaps to the precipitation of aluminum sulfate minerals such as jurbanite ($Al[SO_4][OH]\cdot 5H_2O$).

The effect of acid mine drainage on West Squaw Creek, which is north of Boulder and Spring Creeks and drains into Shasta Lake, has been studied by Filipek et al.[16] They also found low pH and high metal and sulfate concentrations in the creek several miles downgradient of mine sites along West Squaw Creek; however, the pH was generally higher (2.5 to 5.5) than at Boulder and Spring Creeks and the dissolved concentrations were all generally less than 1000 mg/L. They observed an amorphous orange precipitate associated with algae in the stream beds, which they believed was ferric hydroxide or a mixture of ferric hydroxide and jarosite. Elevated arsenic concentrations (>10 μg/L) were reduced to below detection level (1 μg/L) a short distance from the source as the arsenic was removed from solution probably by adsorption onto the precipitating iron minerals. These two sites in the West Shasta Mining District illustrate the high mobility of an acidic, metal-rich solution in an environment with low-neutralizing ability.

Strip mining of coal also has the potential for producing acidic conditions if the coal contains sulfide minerals and has a low-neutralizing capacity. Karathanasis et al.[17] sampled soil solutions and surface water from unreclaimed and partially reclaimed watersheds that had been strip-mined in Kentucky. They found that after almost 20 years since mining ceased, the pH of the surface water and soil was still depressed (2.7 to 4.2) [illegible]

acidic as are surface waters. Stollenwerk[18] investigated the contact of acidic water with alluvial aquifer material in the Globe-Miami copper mining district of Arizona. The most contaminated groundwater near the source had a pH of 3.3 and dissolved concentrations of 9600 mg/L SO_4^{2-}, 2800 mg/L Fe, 300 mg/L Al, and 200 mg/L copper. Uncontaminated parts of the alluvium contained about 0.3 weight % calcite, which provides the primary neutralizing capacity in the aquifer system. Near the source, the calcite had dissolved allowing a low-pH plume to form in the aquifer. Over a distance of 10 km from the source, the pH of the groundwater increased slowly from 3.3 to about 4.3 at which point it increased relatively rapidly over the next two kilometers to 7. The neutralized groundwater has very low Fe, Al, and Cu concentrations (<1 mg/L), while the sulfate level (2000 mg/L) remains well above the background concentration (70 mg/L). The decrease in Fe concentration is attributed to the low solubility of $Fe(OH)_3$ at neutral pH. Dissolved aluminum levels appeared to be limited by the precipitation of amorphous $Al(OH)_3$ at pH > 4.7 and $AlOHSO_4$ at pH < 4.7. The concentration of sulfate is controlled by the relatively soluble mineral gypsum, which explains the high level even in the neutralized water. Attenuation of the metals Cu, Co, Mn, Ni, and Zn along the groundwater flowpath appeared to be controlled by adsorption onto ferrihydrite.

The least likely setting for the occurrence of acid mine drainage is a mine site in carbonate terrain; however, sulfide oxidation can still produce groundwater contamination. The zinc-lead mines near Shullsburg, Wisconsin, are located in a carbonate aquifer. This aquifer was dewatered during mining allowing contact of the sulfide minerals (pyrite, galena [PbS], and sphalerite [ZnS]) with atmospheric air. Toran[19] found that the carbonate minerals dolomite and calcite effectively neutralized acid production and that siderite ($FeCO_3$) and ferrihydrite limited iron concentration to an acceptable level. However, the sulfate level in groundwater allowed to reenter the mine since shutdown of the main mine working in 1979 is elevated (96 to 3800 mg/L) within a half mile of the mine. Calculation of the gypsum saturation indices for groundwater samples showed it to be undersaturated in most cases despite high dissolved levels of calcium and sulfate. If gypsum is present as a byproduct of sulfide mineral oxidation in the mine workings, then the dissolved sulfate from dissolution of this gypsum into the groundwater is diluted by mixing with freshwater a short distance from the workings. Toran concluded that the sulfate contamination is localized and will decrease with time by continued dissolution and removal of the source and dilution of the contaminated groundwater.

Ore Storage, Mine Waste and Tailings Piles

The presence of sulfide-containing ore, mine waste, or mill tailings on the surface of the earth creates a localized environment with a high potential for acid production. Oxidizing water percolating through the material dissolves the sulfide minerals, creating acidic conditions unless the material also contains neutralizing solids. In the long term the overall rate of oxidation will be controlled by the delivery of oxygen to the sulfide minerals. Oxygen can be transported by diffusion in the gas phase for unsaturated conditions and dissolved in the solution phase for saturated conditions.[20] The progression of acidic conditions in the subsurface beneath the pile will be a function of the flux of acidity from the pile and the neutralizing capacity of the native material.

Blowes and Jambor[21] evaluated the porewater geochemistry of sulfide tailings at a

acid generating ability than neutralizing capacity. Geochemical processes other than dissolution of carbonate minerals that can neutralize the acid are dissolution of aluminosilicate minerals, dissolution of Fe- and Al-hydroxide minerals, and H^+ adsorption on mineral surfaces. It is calculated that the acid generated in oxidizing 1 m of tailings requires a 25-m flowpath to be neutralized by these reactions. For this reason the acid plume can move out of the zone of active acid generation into the lower tailings and the native material below the pile.

The calculation of mineral saturation indices allowed Blowes and Jambor to identify possible mineral phases limiting solution composition in this tailings pile. Goethite (α-FeOOH), lepidocrocite (γ-FeOOH), ferrihydrite ($Fe[OH]_3$), jarosite ($KFe_3[SO_4]_2[OH]_6$), and gypsum ($CaSO_4 \cdot 2H_2O$) limit the solution concentrations of the major ions, Fe^{2+}, SO_4^{2-}, Ca^{2+}, Na^+, and K^+ in the pore water. Lead may be limited by anglesite ($PbSO_4$), and Cr may be limited by the precipitation of amorphous $Cr(OH)_3$, while Cu is precipitated as covellite (CuS) below the zone of active oxidation. There do not appear to be any mineral solubility limits on Co, Mn, Ni, or Zn concentrations; therefore it is likely that the migration of these metals through the tailings is primarily affected by adsorption/desorption processes. Given the current rate of oxidation of this tailings pile and the amount of sulfide minerals present, it is calculated that these tailings will continue to generate acid for several centuries unless the oxygen source is cut off or additional neutralizing agents are added.

The precipitation of secondary minerals at different "fronts" in a tailings pile can affect the movement of porewater by forming horizontal barriers to vertical flow. Blowes et al.[22] discuss the occurrence of a discontinuous, cemented layer (hardpan) at the Quebec tailings pile described above. This layer is 1 to 5 cm thick and occurs at the depth of active sulfide mineral oxidation. Cementation is produced by Fe(III) minerals, principally goethite, lepidocrocite, ferrihydrite, and jarosite. At a separate, inactive, sulfide tailings site in New Brunswick, they describe another type of hardpan that is 10 to 15 cm thick and continuous and occurs 20 to 30 cm below the depth of active oxidation at the first appearance of calcite. In this case cementation is caused by the precipitation of gypsum and Fe(II) solid phases, principally, melanterite ($FeSO_4 \cdot 7H_2O$). The lack of precipitation of the Fe(III) oxide and sulfate minerals at this site is attributed to a higher sulfide content in the tailings and a lower pH, which increases the solubility of the Fe(III) minerals, minimizing their formation. Concentrations of Fe(II) and sulfate increase until melanterite becomes supersaturated. Gypsum also precipitates when calcite is encountered because the dissolution of calcite releases calcium that can combine with sulfate to form gypsum. The presence of these hardpan layers in the tailings piles are viewed as a benefit because they limit the movement of solution and gases through the reactive tailings material.

Pyrite is a ubiquitous constituent in coal. In a review of water-quality issues associated with coal storage, Davis and Boegly[23] compile data on leachate from coal storage piles. They found pH values as low as 2.1, iron concentrations as high as 93,000 mg/L, and sulfate levels to 22,000 mg/L. Concentrations of Zn, Pb, As, Cu, Cr, and Al exceeded 1 mg/L in the majority of the tabulated leachate compositions. Helz et al.[24] identified the minerals melanterite ($FeSO_4 \cdot 7H_2O$) and ferrihydrite as concentration-limiting minerals in a leaching study of Appalachian coals. These minerals are fairly soluble under the conditions of the coal pile and do not limit solution concentrations to low levels. They recommend evaluating the addition of limestone to coal piles

many of these sites it has been found that the pH of the leachate is raised from a value of less than 2 in the tailings to near neutral by contact with less than one meter of subsurface native material. Most of these sites are in the arid to semiarid western United States where calcite is a common primary or secondary mineral in the soil. Calcite neutralizes the acid, leading to the precipitation of other minerals such as ferrihydrite, gypsum, $Al(OH)_3$, and $AlOHSO_4$ (at low pH). Other metal contaminants and radionuclides associated with the leachate appear to be adsorbed or coprecipitated with these secondary minerals. The most mobile contaminant at these sites is usually sulfate, which is present at elevated concentrations in groundwater because of the relatively high solubility of gypsum.

Acid Lakes

Lakes and other surface water bodies may become acidic because of the inflow of acid waters from mine workings, as in the case of mine pit lakes, or because of acid precipitation in regions of elevated atmospheric content of acid-producing gases, especially SO_x and NO_x. The geochemistry of these two environments with respect to acid generation and neutralization is discussed in this section.

Mine Pit Lakes

Open-pit, hard-rock mining for metals commonly extends below the water table and requires dewatering during the mining process. At the cessation of mining, the pit fills with water to the level of the water table creating a lake that may be very large (containing >10,000 acre-feet of water). Water-quality issues associated with these lakes have been reviewed by Miller et al.[29] Because of the presence of sulfide minerals associated with the ore material and the exposure of these minerals to atmospheric conditions during mining, water draining into the pit has the potential to be acidic. The deeper the pit, the more likely that reducing conditions will be encountered and pyrite present in the host rock. Data compiled by Miller et al. for the Berkeley Pit (Butte, Montana) and the Liberty Pit (White Pine County, Nevada) show pH values of 2.8 and 3.21, respectively; Fe, Cu, and Zn concentrations greater than 50 mg/L; and sulfate greater than 3500 mg/L. Saturation index calculations for water in the Berkeley Pit showed that the minerals ferrihydrite, gypsum, jurbanite ($AlOHSO_4$), and jarosite ($KFe_3[SO_4]_2[OH]_6$) provide solubility limits for the dissolved constituents under acidic conditions.[30]

In cases where the capacity of the system is sufficient to neutralize acid generation, the pH values are not depressed. For example, in the lakes at the Kimberly Pit (White Pine County, Nevada) and the South Pit, Getchell Mine (northern Nevada), the pH values are 7.61 and 5.96, respectively.[29] Elevated sulfate concentrations (>1000 mg/L) suggest that sulfide mineral oxidation is occurring at these sites, but, in general, metals concentrations are not significantly elevated because of the low solubility of their minerals and/or high-adsorption affinity at these near-neutral pH values. However, arsenic is of potential concern in the more neutral lake environments because it is less strongly adsorbed at high pH (>6.5) than under acidic conditions. At the Getchell Mine the arsenic concentration is 40 times greater in the higher pH (7.67) North Pit lake than in the South Pit lake (pH = 5.96).

Acid-Impacted Natural Lakes

Lakes downwind of coal-fired power plants and industries that burn sulfur-containing coal can become acidified by the introduction of acid-producing gases (principally SO_x) into

In areas where the neutralizing capacity of the system is sufficient, the pH of the lake will not be depressed. However, in the northeastern United States where the natural neutralization capacity is low because of the lack of carbonate minerals and relatively high natural organic acid content of runoff, this additional acid from atmospheric deposition may depress the pH of the lake. For example, at Woods Lake (New York) the acidic precipitation has a mean pH of 3.96 and the pH of the lake due to this anthropogenic acidic deposition is 5.0.[31]

The fate of sulfate in surface water may also have an impact on lake acidity. Sulfate may be tied up in the sediments as organic S compounds or reduced inorganic S. In a study of eight acid lakes in Quebec, Carignan and Tessier[11] found that the majority of the anthropogenically derived excess S was tied up in the sediments as reduced inorganic iron minerals such as FeS and pyrite. As shown by Reaction 12-15, the reduction of Fe(III) and SO_4^{2-} in the sediments by organic matter, as facilitated by sulfate-reducing bacteria, produces not only the iron sulfide minerals but bicarbonate in solution. Additional sulfate-reducing reactions postulated by Carignan and Tessier are as follows:

$$8CH_2O + 4SO_4^{2-} + 2O_2 \rightarrow 4S^0(s) + 8HCO_3^- + 4H_2O \qquad (12\text{-}17)$$

$$17CH_2O + 8SO_4^{2-} + 4Fe(OH)_3(s) + 2O_2 \rightarrow 4FeS_2(s) + 16HCO_3^- + 15H_2O + CO_2 \qquad (12\text{-}18)$$

In each case the reduction of one mole of sulfate produces two moles of alkalinity as represented by HCO_3^-. The bicarbonate produced in the sediments can participate in acid neutralization by the following reaction:

$$HCO_3^- + H^+ \rightarrow H_2CO_3 \qquad (12\text{-}19)$$

Herlihy et al.[10] also showed that for a lake in Virginia that received acid mine drainage, the major sink for iron and sulfate was bacterial sulfate reduction and the precipitation of FeS in sediments. As long as the sulfide minerals are stable in the reduced condition of the sediment and are not reoxidized, this mechanism of creating neutralizing capacity will be effective.

In some sediments Carignan and Tessier found that the Fe(III) reserve available to form iron sulfide minerals was nearly or completely exhausted. These lakes will have a lower capacity to neutralize acid input through the process of sulfate reduction and bicarbonate production. In lakes with less available iron it is more likely that the sulfur in sediments will be contained in organic S compounds.

The presence of acidic conditions in surface water should not always be attributed to anthropogenic pollutants. In a study of the factors controlling acidity in the River Lillån, northern Sweden (pH = 5.18), Jansson and Ivarsson[32] found that the acidity in 38 small tributary streams to the river was caused principally by naturally occurring organic acids. The dissolved organic carbon in most of the streams varied between 10 and 30 mg/L. During periods of rainstorms the precipitation flushed organic acids from the forest soils and lowered the pH in the streams from 6.5–7.0 to 4.5–5.0. The movement of humic

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Aqueous Environmental Geochemistry

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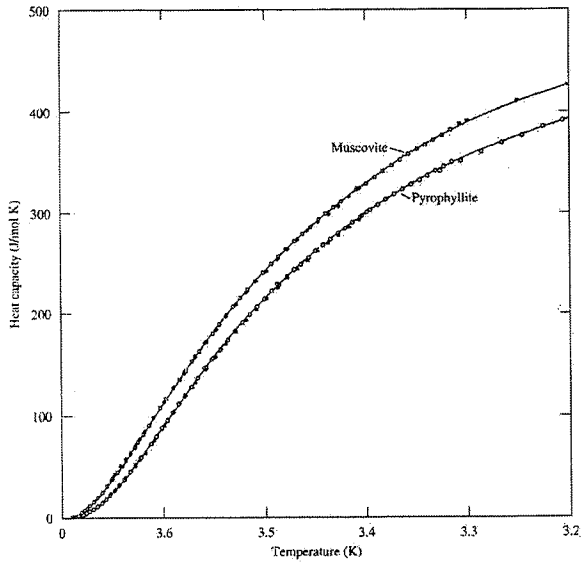

Figure 1.1 Low temperature heat capacities of muscovite $[KAl_2(AlSi_3O_{10})(OH)_2]$ and pyrophyllite $[Al_2Si_4O_{10}(OH)_2]$. The heat capacity in joules per mole degree (J/mol K) divided by 4.184 equals the heat capacity in calories per mole degree (cal/mol K). From Robie et al. (1976).

The third-law entropy of substances usually equals zero at $T(K) = 0$. A plot of the measured heat capacity of the minerals muscovite and pyrophyllite is shown in Fig. 1.1. To determine ΔS_T° for either mineral, we integrate the above function below the empirical curve from 0 to $T(K)$. (See Wood and Fraser 1976; Nordstrom and Munoz 1994.)

The entropy of dissolved species is approached quite differently. We cannot know (and do not need to know) their absolute entropies. Instead, we consider the differences in S (or ΔS) between an aqueous species and H^+ ion, assuming S_T for the $H^+(aq) = 0$. Treatment of the thermodynamic properties of aqueous species is addressed in more detail later.

Entropy is a measure of the degree of randomness or disorder of a phase (thermal, statistical, or the geometric arrangement of the atoms, for example). The most order exists at 0 (K), where $S = 0$ for most substances. With changes of state from solid to liquid to gas, the entropy increases discontinuously with increasing disorder of the phase. Thus, for H_2O at 25°C

$$S^\circ \text{ (ice } I\text{) (metastable)} < S^\circ \text{ (water)} < S^\circ \text{ (steam)} \tag{1.15}$$

10.68 < 16.72 < 45.11 cal/mol K

(For further useful entropy references see Krauskopf 1967; Lewis and Randall 1961; Wood and Fraser 1976; Stumm and Morgan 1981; Henderson 1982; Mason and Moore 1982.)

1.3 GIBBS FREE ENERGY, CHEMICAL POTENTIAL, AND THE EQUILIBRIUM CONSTANT

The Gibbs free energy (G_i) of a substance i is defined as $G_i = H_i - TS_i$. Free energy cannot be measured directly. As with enthalpy, we consider the difference (ΔG) between the free energies of substances in a reaction. The ΔG for a reaction is the maximum energy change for that reaction as useful work, measured at constant temperature and pressure. For a reaction we can write

$$\Delta G_r^\circ = \Delta H_r^\circ - T\Delta S_r^\circ \tag{1.16}$$

This is a most important, fundamental relationship.

Next we will show how ΔG_r° is related to the equilibrium constant (K_{eq}) for a reaction. Consider the general reaction

$$aA + bB = cC + dD \tag{1.17}$$

where the lowercase letters denote the number of moles of reactants A and B and products C and D. The Gibbs free energy of a mole of A at some pressure and temperature is G_A. This is also the definition of the chemical potential of A, or $G_A = \mu_A$. We can also write

$$G_A = \Delta G_A^\circ + RT\ln[A] \tag{1.18}$$

where T is in degrees K, and ΔG_A° is the standard molar Gibbs free energy of A. ΔG_A° is the Gibbs free energy of A at unit activity of A (when $[A] = 1$). The activity of A can be roughly thought of as the fraction of its total concentration that participates in reactions. For ions the activity of A is usually less than its concentration. (See Chap. 3).

For a moles of A, $aG_A = a\Delta G_A^\circ + RT\ln[A]^a$. Now ΔG_r for the general reaction equals the difference in the sum of values for the products minus that for the reactants

$$\Delta G_r = cG_C + dG_D - aG_A - bG_B \tag{1.19}$$

Introducing expressions for the other reacting substances similar to that for A, we obtain

$$\begin{aligned}\Delta G_r = [c\Delta G_C^\circ + d\Delta G_D^\circ - a\Delta G_A^\circ - b\Delta G_B^\circ] + RT\ln[C]^c + RT\ln[D]^d \\ - RT\ln[A]^a - RT\ln[B]^b\end{aligned} \tag{1.20}$$

Collecting and combining terms

$$\Delta G_r = \Delta G_r^\circ + RT\ln\frac{[C]^c[D]^d}{[A]^a[B]^b} \tag{1.21}$$

where ΔG_r°, which equals the bracketed difference in terms in the previous equation, is the standard Gibbs free energy of the reaction. The ratio of concentrations on the right may be called the reaction quotient, Q. At equilibrium $\Delta G_r = 0$ and $Q = K_{eq}$ or

$$\Delta G_r^\circ = -RT\ln\frac{[C]^c[D]^d}{[A]^a[B]^b} \tag{1.22}$$

or simply

$$\Delta G_r^\circ = -RT\ln K_{eq} \tag{1.23}$$

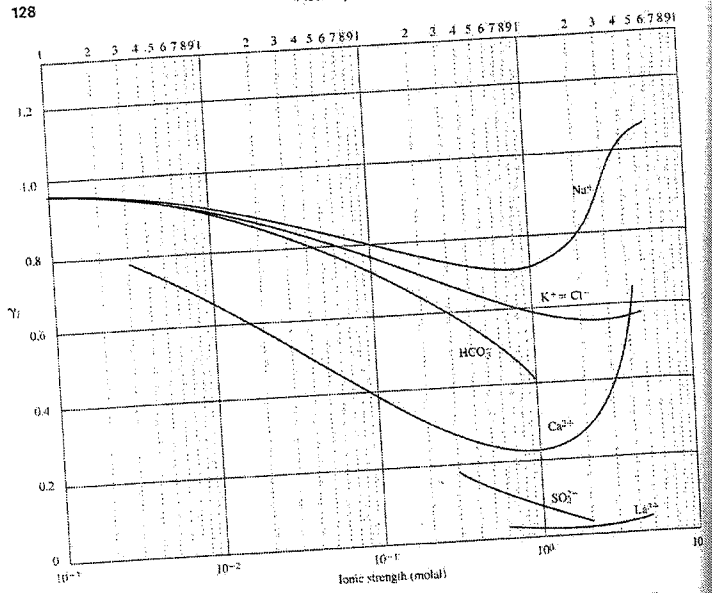

Figure 4.2 Some individual ion activity coefficients computed from mean salt data assuming the MacInnes convention.

use of the theoretical Debye-Hückel equation (c.f. Robinson and Stokes 1970). Assumptions inher ent in this equation include that ion interactions are purely Coulombic, ion size does not vary with ionic strength, and ions of the same sign do not interact. For individual ions the equation is

$$\log \gamma_i = \frac{-A z_i^2 \sqrt{I}}{1 + B a_i \sqrt{I}} \tag{4.28}$$

where $A = 1.824928 \times 10^6 \rho_o^{1/2} (\epsilon T)^{-3/2}$, $B = 50.3 (\epsilon T)^{-1/2}$, with ρ_o the density of water, ϵ the dielec- tric constant of water, and T in kelvin. At 25°C, $\rho_o = 0.99707$, $\epsilon = 78.4528$, $A = 0.5092$, and $B =$ 0.3283 (Helgeson and Kirkham 1974).

At other temperatures the dielectric constant of water can be obtained from the equation

$$\epsilon = 2727.586 + 0.6224107\, T - 466.9151 \ln T - 52000.87/T \tag{4.29}$$

where T is in kelvin. This function fits empirical values of ϵ to within ±0.01 units up to 100°C (Nord- strom et al. 1990). The dielectric constant of water is a measure of the effect of water (versus a vac- uum) in decreasing the force (F) of the electrical field between ionic species in solution, where $F =$ $z_1 z_2 / \epsilon r^2$ and z_1 and z_2 are the charges on ions 1 and 2, and r is the distance between them. The di-

electric constant is determined by measuring the capacitance of water, $\mathbb{C}_{H_2O}$ versus that of a vacuum, $\mathbb{C}_o$, or $\epsilon = \mathbb{C}_{H_2O}/\mathbb{C}_o$.

The term a_i is the effective size of the hydrated ion in angstroms (1 Å = 1 nm = 10^{-8} cm) and is a function of the degree of hydration of the ion, which is roughly proportional to its ionic potential (its charge z over radius r [see below]. Given in Table 4.1 are ion size parameters for many inorganic and organic species based chiefly on Kielland (1937). According to Kielland (1937) a_i values for inorganic ions range from 2.5 to 4.5 for monovalent ions, (except for Li^+ and H^+), 4 to 8 for divalent ions, 4 to 9 for trivalent ions, and 5 to 11 for quadrivalent ions. The anomalous size of the proton (a_i = 9) reflects its occurrence in the large hydronium ion (H_3O^+) and in similar hydrated species.

Some ion activity coefficients at 25°C computed with the Debye-Hückel equation as a function of ionic strength, ion size, and charge, are shown in Table 4.2. Debye-Hückel ion activity coefficients up to 0.1 mol/kg ionic strength, are plotted in Fig. 4.3 for some monovalent and divalent ions. The Debye-Hückel equation can be used to compute accurate activity coefficients for monovalent ions up to about $I = 0.1$ mol/kg, for divalent ions to about $I = 0.01$ mol/kg, and for trivalent ions up to perhaps $I = 0.001$ mol/kg.

At ionic strengths between 0.001 and 0.0001 mol/kg the separate curves for individual ions of the same valence converge on a single curve. At these low ionic strengths, the term $B\, a_i \sqrt{I}$ approaches zero, and the Debye-Hückel equation is reduced to

$$\log \gamma_i = -A z_i^2 \sqrt{I} \tag{4.30}$$

This is called the Debye-Hückel limiting law. At higher ionic strengths, differences in ion sizes (a_i values) become important and cause the γ_i curves for individual ions to diverge.

The effect of temperature on ion activity coefficients is largely predicted by changes in the value of A, which is proportional to $-\log \gamma_i$ in the Debye-Hückel equation. The value of A increases from 0.492 to 0.534 between 0 and 50°C. Thus, activity coefficients become smaller with increasing temperature. Because A is multiplied by z^2 in the Debye-Hückel equation, the effect of temperature on activity coefficients is greatest for multivalent ions.

4.2.3 Intermediate Ionic Strengths: The Davies and Truesdell-Jones Equations, Specific Ion-Interaction Theory

Examination of Figs. 4.1 and 4.2 shows that individual and mean ion activity coefficients generally decrease to minimal values between 1 and 10 mol/kg, and then increase at higher ionic strengths. However, the form of the Debye-Hückel equation is such that it predicts γ values that decline continuously with ionic strength. Several assumptions incorporated in the Debye-Hückel equation become invalid and lead to its failure at high ionic strengths where ion activity coefficients increase (cf. Pytkowicz 1983). These assumptions include: ion interactions are purely coulombic, ion size does not vary with I, and ions of the same sign do not interact. Chemical equilibria calculations in seawater ($I = 0.7$ mol/kg) and in higher ionic strength brines require activity coefficient models without such limitations.

The increase in ion activity coefficients at elevated ionic strengths results from several effects, including the fact that an increasing fraction of water molecules are involved in hydration spheres around ions. This causes a proportionate decrease in the concentration of free water molecules in the solution. For example, assuming there are six water molecules associated with each pair of dissolved Na^+ and Cl^- ions in a 0.01 molar NaCl solution (see Bockris and Reddy 1973), the moles of free water molecules in a liter of solution are $55.5 - 6 \times (0.01) = 55.44$. On the other hand, if the solution

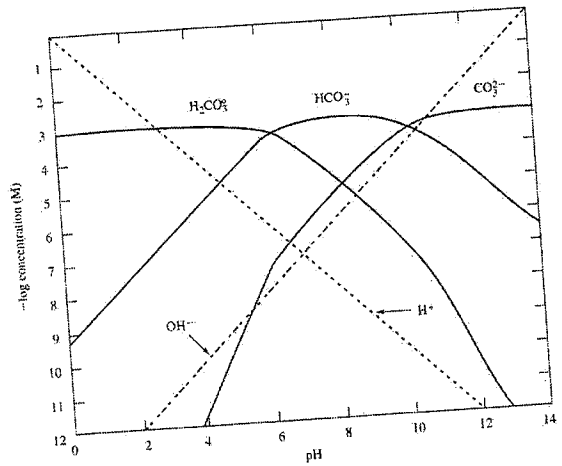

Figure 5.2 Distribution diagram for carbonate species as a function of pH, assuming $C_T = 10^{-3}$ M. Concentrations of H^+ and OH^-, which are independent of C_T, are shown as dashed straight lines.

on pH. Remember that when free protons are consumed in reactions that produce carbon dioxide and/or carbonic acid (a weak acid), the pH will rise, and conversely. Among the reactions and processes listed in the table, some operate in both surface-water and groundwater systems, whereas others are largely limited to one or the other.

The carbon dioxide content of surface water tends toward a limiting value defined by Henry's law and the CO_2 pressure in the atmosphere (0.00033 bar or $10^{-3.5}$ bar). Differences from $10^{-3.5}$ bar CO_2 pressure reflect relative rates of reactions and processes, including (1) through (9) in Table 5.3.

Some surface waters (deep, stratified, and poorly mixed, with little sunlight penetration, heavily polluted) are physically isolated from the atmosphere. In such waters, the apparent CO_2 pressure, which is defined by $P_{CO_2} = [H_2CO_3^*]/K_{CO_2}$ will usually exceed the atmospheric value. This disequilibrium partly reflects the fact that the rate of CO_2 degassing from water is slower than its rate of gaseous uptake from the atmosphere (cf. Schmiermund 1991; Morel and Hering 1993; Cole et al. 1994).

In a study of lakes worldwide (4665 samples from 1835 lakes) Cole et al. (1994) found the pH ranged from about 4 to 10 and CO_2 pressures from about $10^{-1.7}$ to $10^{-6.0}$ bar. Sources of CO_2 in lakes include its inflow in surface waters and groundwaters and respiration and decay related to lake sediments and biota. The overall mean CO_2 pressure of 1.049×10^{-3} ($10^{-2.98}$) bar in lakes was three times greater than the atmospheric value. This reflects a CO_2 production and accumulation rate that exceeds its rates of consumption in the growth of aquatic plants and rate of degassing to the atmosphere.

(p 156)
P = 0.00033 bar

TABLE 5.3 Some important processes and reactions that control the CO_2 content of surface- and groundwaters and, therefore, their pH

Processes and reactions	pH up or down
1. $CO_2(g)$ dissolution →, $CO_2(aq)$ exsolution ← $CO_2(g) + H_2O \leftrightarrow CO_2(aq) + H_2O \leftrightarrow H_2CO_3^*$	→down/←up
2. Photosynthesis[a] →, respiration & aerobic decay ← $CO_2 + H_2O \leftrightarrow 1/6\ C_6H_{12}O_6$ (glucose) $+ O_2$	→up/←down
3. Methane fermentation (anaerobic decay) → $C_6H_{12}O_6$ (glucose) $\rightarrow 3CH_4 + H_2O + CO_2$	→down
4. Nitrate uptake and reduction → $NO_3^- + 2H^+ + 2CH_2O \rightarrow NH_4^+ + 2CO_2 + H_2O$	→up
5. Denitrification → $5CH_2O + 4NO_3^- + 4H^+ \rightarrow 5CO_2 + 2N_2 + 7H_2O$	→up
6. Sulfate reduction → $2CH_2O + SO_4^{2-} + H^+ \rightarrow 2CO_2 + HS^- + 2H_2O$	→up
7. Carbonate mineral dissolution → or precipitation ← $CaCO_3$(calcite) $+ H^+ = Ca^{2+} + H_2O + CO_2$ $NaHCO_3$(nahcolite) $+ H^+ = Na^+ + H_2O + CO_2$	→up/←down
8. Common-ion driven calcite precipitation → $CaSO_4 \cdot 2H_2O + 2HCO_3^- \rightarrow CaCO_3 + SO_4^{2-} + 2H_2O + CO_2$ gypsum calcite	→down
9. Chemical weathering of Al-silicate minerals $2KAlSi_3O_8 + 2CO_2 + 11H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2K^+ + 2HCO_3^-$ K-feldspar kaolinite	→up

Note: CH_2O represents organic matter.
[a]Other reactions that lead to carbon fixation may involve species of S and N (cf. Morel & Hering 1993; Stumm and Morgan 1996).

Some of the lowest apparent CO_2 pressures (and related highest pH's) found in lakes and other surface waters result from the photosynthetic activity of aquatic vegetation (reaction 2→) around midday, removing CO_2 far more rapidly than it can be replenished from the atmosphere (reaction 1→), from respiration and decay (reactions 2← and 3→), or from groundwater inflow to the surface water. (Groundwaters usually contain more CO_2 than surface waters.) The highest pH's due to photosynthesis are found in streams, lakes, and reservoirs clogged with green algae (waters that have a high biomass/water ratio).

The highest apparent CO_2 pressures in surface waters may occur at night, when the dominant processes are respiration and aerobic decay (reaction 2←), and perhaps groundwater inflow. Such behavior is reflected in the data from a study of Slab Cabin Run, near State College, Pennsylvania, given in Table 5.4 (Jacobson et al. 1971). Slab Cabin Run is a small stream fed by carbonate springs and often clogged with photosynthetic aquatic vegetation. The apparent CO_2 pressures for the stream in Table 5.4 have been computed from the total analysis using MINTEQA2. Measurements at 4:45 A.M. on a summer day showed a minimum stream pH of 7.76 and maximum apparent CO_2 pressure of $10^{-2.68}$ bar, probably reflecting chiefly the chemistry of groundwater inflow. At 2 P.M. that same day, active photosynthesis by aquatic vegetation produced a maximum stream pH of 9.42 and corresponding reduction in the apparent CO_2 pressure to $10^{-4.41}$ bar.

Note that the equivalents of acidity due to each cationic species, or the number of protons it can donate, equals the charge of that species.

5.7 ALKALINITY

Alkalinity is the capacity of a water to accept protons and is the sum effect of all bases present. In most potable waters the alkalinity is due chiefly to bicarbonate ion and, to a minor extent, carbonate, ion. *Carbonate alkalinity* is defined as HCO_3^- + $2CO_3^{2-}$. Hydroxyl, when present (usually unimportant below about pH 10), is called *caustic alkalinity*. The conventional definition of total alkalinity (C_B) in eq/L or meq/L, is

$$C_B = HCO_3^- + 2CO_3^{2-} + OH^- - H^+ \tag{5.43}$$

or, in other words, C_B equals the total equivalents of bases minus those of acids. Other bases that can contribute to total alkalinity are the ligands of fulvic acid; organic acid anions such as formate, propionate, and acetate (cf. Lundergard and Kharaka 1990) and bisulfide, orthophosphates, ammonia, borate, and silicates. Alkalinity is usually reported as mg/L $CaCO_3$ or meq/L $CaCO_3$. A useful conversion is C_B (or C_A) as mg/L $CaCO_3$ = C_B (or C_A) as meq/L × 50.04.

In potable waters below about pH 8.3, bicarbonate is usually the only significant base. Bicarbonate alkalinity in water derives from two sources: (1) the weathering of silicate and carbonate minerals by carbonic acid, for example

$$\underset{\text{K-feldspar}}{2KAlSi_3O_8} + \underset{\text{carbonic acid}}{2H_2CO_3^\circ} + 9H_2O = \underset{\text{kaolinite clay}}{Al_2Si_2O_5(OH)_4} + 2K^+ + \underset{\text{silicic acid}}{4H_4SiO_4^\circ} + 2HCO_3^- \tag{5.44}$$

and (2) the dissolution of carbonate minerals, which, if dissolved by carbonic acid, contributes twice as much bicarbonate alkalinity relative to $H_2CO_3^\circ$ consumed as does silicate weathering. For example,

$$\underset{\text{dolomite}}{CaMg(CO_3)_2} + 2H_2CO_3^\circ = Ca^{2+} + Mg^{2+} + 4HCO_3^- \tag{5.45}$$

Bicarbonate ion is usually the chief anion in freshwaters. In and on silicate rocks, the HCO_3^- concentration is usually 50 to 200 mg/L, whereas in groundwaters that contact a few percent carbonate materials up to pure limestone and dolomite, bicarbonate levels are usually in the range of 200 to 400 ppm. Seawater contains 140 mg/L HCO_3^-. Carbonate alkalinity (CO_3^{2-}) rarely exceeds 10 mg/L. Why? The presence of caustic alkalinity (free OH^-) at pH's above 10 usually indicates artificial contamination of a water by, for example, $Ca(OH)_2$ (portlandite) from the setting of concrete at newly completed wells. C_B concentrations can reach 1000 ppm as HCO_3^- in sodium carbonate-bicarbonate brines found in evaporative, closed basin lakes.

For natural waters in which the only acids and bases are species of carbonic acid and strong acids or bases, there is a simple relationship between C_A, C_B, and the total carbonate, C_T. Remember that the simple definitions of these parameters are:

$$C_T = H_2CO_3^\circ + HCO_3^- + CO_3^{2-} \tag{5.21}$$

$$C_A = 2H_2CO_3^\circ + HCO_3^- + H^+ - OH^- \tag{5.41}$$

and

$$C_B = HCO_3^- + 2CO_3^{2-} + OH^- - H^+ \tag{5.43}$$

Algebraic manipulation shows that these expressions are related in the equation

$$2C_T = C_A + C_B \tag{5.46}$$

5.8 ACID-BASE PROPERTIES OF MINERALS AND ROCKS

Most minerals are salts of weak acids and strong bases. The weak acids include silicic and carbonic acids. The strong bases are, for example, NaOH, KOH, and $Ca(OH)_2$. Because of their weak acid–strong base character, most minerals are stable under alkaline conditions, but tend to dissolve under acid conditions. Consistent with this behavior, when ground-up silicate and aluminosilicate minerals are placed in pure water, the pH generally rises to alkaline values. Such behavior gives most important rocks and minerals (but not quartz, SiO_2) a substantial alkalinity that can neutralize natural or contaminant acidity. The rate of such neutralization is relatively fast for carbonate rocks, but slow for most silicate rocks, except the clays. The neutralization process is called chemical weathering and is dealt with in more detail in Chap. 7. Typical weathering reactions are the dissolution of calcite and the weathering of potassium feldspar to form kaolinite clay (see Table 5.3).

A few minerals produce acid when they contact water. These minerals can be described as salts of weak bases and strong acids. They chiefly result from weathering and oxidation of the pyrite or marcasite (FeS_2) exposed in the mining of mineral deposits and coal. Such acid minerals, which are dominantly Fe^{3+} sulfates and to a minor extent Al^{3+} sulfates, typically form from the evaporation of pooled acid-mine waters or of the moisture in unsaturated mine wastes or spoils that contain the sulfides. Acidity is produced when they are dissolved by fresh runoff or recharge. For example

$$Fe_2(SO_4)_3 \cdot nH_2O = 2Fe^{3+} + 3SO_4^{2-} + nH_2O \tag{5.47}$$

where n = 6 in lausenite, 7 in kornelite, 9 in paracoquimbite and coquimbite, and 10 in quenstedtite (Palache et al. 1951). Acidity is produced by hydrolysis of the ferric iron,

$$Fe^{3+} + 3H_2O = Fe(OH)_3(ppt) + 3H^+ \tag{5.48}$$

More common minerals in such a setting are jarosite and alunite, which often dissolve incongruently to form their oxyhydroxides, releasing protons. The jarosite reaction produces significant acidity, whereas alunite is a very weak acid. For the reaction

$$\underset{\text{jarosite}}{KFe_3(SO_4)_2(OH)_6} + 3H_2O = K^+ + 3Fe(OH)_3(ppt) + 2SO_4^{2-} + 3H^+ \tag{5.49}$$

$$K_{eq} = [K^+][SO_4^{2-}]^2[H^+]^3 = 10^{-19.5} \tag{5.50}$$

Assuming that $K_{sp} = 10^{-39}$ for the ferric oxyhydroxide and K_{sp}(jarosite) = $10^{-94.5}$, and given $[K^+] = 10^{-3}$ mol/kg and $[SO_4^{2-}] = 10^{-2.5}$ mol/kg, and ignoring activity coefficients, the pH for equilibrium with jarosite is 3.8.

The pH at equilibrium with the aluminum sulfate salts on the other hand, is near neutral. For alunite in equilibrium with amorphous aluminum hydroxide, the reaction is

$$\underset{\text{alunite}}{KAl_3(SO_4)_2(OH)_6} + 3H_2O = K^+ + 3Al(OH)_3(ppt) + 2SO_4^{2-} + 3H^+ \tag{5.51}$$

for which $K_{eq} = 10^{-28.3}$, assuming $K_{sp} = 10^{-33}$ for the aluminum oxyhydroxide and K_{sp}(alunite) = $10^{-85.3}$. Again, given $[K^+] = 10^{-3}$ mol/kg, and $[SO_4^{2-}] = 10^{-2.5}$ mol/kg, and ignoring activity coefficients, the equilibrium pH is 6.8.

TABLE 10.5 Measured cation exchange capacities, in situ soil pH values and percentages of major exchangeable ions of some soils at pH = 7

Soil	pH	CEC	Equivalent Percent of CEC					
			H	K	Na	Ca	Mg	Mn
Morrison sandy loam subsoil (5 ft depth)	~5	3.4	50	3	3	3	24	18
Lanna soil	4.6	17.3	34	2	1	48	16	—
California soils	7	20.3	—	6	3	66	26	—
Holland soils	7	38.3	—	2	6	79	13	—
Merced clay loam	10	18.9	0	5	95	0	0	—

Note: Dashes indicate no available data.

Source: From Grim (1968), Wiklander (1964), and Apgar and Langmuir (1971).

Given in Table 10.5 are measured, total CEC values for some soils, along with the equivalent percents of different adsorbed cations making up the exchangeable CEC and corresponding pH's. The CEC values reported in the soils literature have usually been measured at pH 7. Figures 10.2 and 10.5 show that CEC values for the oxides and kaolinite are a strong function of pH, so that a CEC measured at pH 7 for these phases is in serious error if assumed for other pH's. For the bentonite (a smectite clay) and the illite, surface charge is relatively independent of pH, so that the CEC measured at pH 7 has more general value.

Note the relative concentrations of H^+ ion and other cations as percents of the soil CEC values in Table 10.5. Important ions adsorbed on soils, but rarely measured, may include NH_4^+, and on waterlogged soils may also include Fe^{2+} and Mn^{2+}. The data in Table 10.5 show that below about pH 5, protons occupy a large fraction of clay surface sites. Below pH 3 to 4, protons occupy all the sites and tend to destroy clay structures. This, of course, makes it difficult to study the surface and sorptive properties of clays in acid solutions. The proton competes effectively with other cations for exchange sites, even when its concentration is 10 to 100 times less than that of the cations.

The total CEC values of soils reflect the variable contributions of organic matter, clay minerals, and ferric and Mn oxyhydroxides. The high CEC of natural organic matter (humic substances), which is typically between 150 to 300 meq/100g, derives from its carboxyl (COOH) groups, which deprotonate at the pH of most natural waters (Thurman 1985). The high CEC values for waterlogged soils (up to 15 meq/100 g for New Jersey soils, according to Toth and Ott 1970) probably result from their high organic contents. The CEC of soils is generally highest in the A and B horizons, where humic substances and clays are most abundant (Thurman 1985). Apgar and Langmuir (1971) measured CEC values of only a few meq/100 g in C-horizon soils in central Pennsylvania. In these soils organic matter was absent, and clays such as kaolinite and illite made up about 20 to 40% of the soil.

According to Toth and Ott (1970), about 80% of the CEC of modern river and estuarine sediments is due to fresh organic matter. These authors found that sediments from the Delaware River, Chesapeake Bay, and Barnegat Bay were 2 to 24% organic matter and had a mean CEC of 57 meq/100 g. Of this mean CEC, organic sorbents contributed 41 meq/100 g, and inorganic sorbents 16 meq/100 g.

In soils and in bottom sediments associated with streams and other surface-waters, the CEC is highest for fine-grained materials, and decreases rapidly with increasing particle sizes. Bodek et al. (1988) report the following CEC values in meq/100 g for different soil-size ranges: sand, 2 to 35;

TABLE 10.6 Cation exchange capacity and time for 50% exchange of K^+ onto Mattole River sediments of increasing size from clay to fine gravel

Size fraction	Total CEC (meq/100 g)	CEC organic fraction (meq/100 g)	Time for 50% exchange
Clay (<2 μm)	53 to 38	47 to 34	2 to 3 s
Silt (2 to 62 μm)	18 to 6	16 to 6	3 to 5 s
Sand (0.06 to 2 mm)	8 to 7	7.5 to 6	8 to 3,000 s
Fine gravel (2 to 9.5 mm)	8 to 6.4	7.4 to 6.4	10,000 s (3 h)

Source: Data from Malcolm and Kennedy (1970).

sandy loam, 2.3 to 17.1; loam, 7.5 to 15.9; silt-loam, 9.4 to 26.3; and clay and clay-loam, 4 to 57.5. For Mattole River sediments, Kennedy and Malcolm (1977) observed that clay-sized materials (<2 μm) had a CEC of 38 to 53 meq/100 g. The CEC of fine gravel (2 to 9.5 mm) ranged from 6.4 to 8 meq/100 g.

In a survey of U.S. stream sediments, Kennedy (1965) concluded that the makeup and properties of the stream sediments essentially equaled that of local soils. In the eastern states (50 to 150 cm precipitation), dominant clays in the <4 μm (0.004 mm) fraction were illite, kaolinite, vermiculite, and interlayered clays, with a CEC of 14 to 28 meq/100 g. In central and west-central states (25 to 100 cm precipitation) Kennedy found dominant smectite, vermiculite, mixed-layer illite, kaolinite, quartz, and feldspar in the <4 μm fraction, with a CEC range of 25 to 65 meq/100 g. In California and Oregon, because of the wide range of wet and dry conditions (<25 to >200 cm precipitation), clays were highly variable, and had a range of CEC's from 18 to 65 meq/100 g for the <4 μm fraction.

The rate of attainment of equilibrium in exchange reactions is fastest when clay-sized materials are involved and sorbate ions can directly contact surface sites. In larger-sized materials, including rock fragments and in rock matrix, however, the attainment of adsorption equilibrium is limited by the much slower rate of diffusion of sorbing species into and out of rock pores (cf. Jenne 1995). This point is illustrated by the measurements of Malcolm and Kennedy (1970), who studied the rate of exchange of K^+ ion by different size fractions of Mattole River sediments using a potassium-specific ion electrode. Their results are summarized in Table 10.6. Complete exchange took 1 to 2 days in the fine gravel. Such effects are also important in fractured rock where most groundwater flow and solute transport occurs in fractures, but diffusion of sorbing solutes from the fractures into adjacent rock matrix takes place (cf. Skagius and Neretnieks 1988; Schwarzenbach et al. 1993).

10.2 SORPTION ISOTHERMS AND THE DISTRIBUTION COEFFICIENT

10.2.1 The Freundlich Adsorption Isotherm and the Distribution Coefficient K_d

It is generally observed that as the concentration of a species in solution increases, the amount of it sorbed (attached in some way) to contacting solid (sorbent) surfaces also increases. A plot that describes the amount of a species sorbed (the sorbate) as a function of its concentration in solution, measured at constant temperature, is called a sorption isotherm. A simple sorption isotherm is shown

sediment or may be solids that have precipitated, such as metal carbonates and Al, Fe(III), and Mn(IV) oxyhydroxides. The trace elements may precipitate in their own pure solids, but most often are coprecipitated as trace species in the major element solids. The K_d approach has been used to describe the removal of trace elements from solution by all of these mechanisms combined. Such a lumped process approach is strongly discouraged in that resultant K_d values only describe the behavior of the system in which they were measured. Assuming a single K_d value for predicting the removal of a dissolved species from streams, soils, and groundwaters, usually leads to serious error for species that form strong complexes, precipitate in insoluble solids or are subject to oxidation or reduction. Lumped-process K_d values (apparent K_d's) for such species can vary nonlinearly by many orders of magnitude between pH 2 and 6. (See Fig. 10.8.)

When K_d values dominantly reflect a sorption process, it has been found that log K_d often varies linearly with pH for at least several pH units. For example, measurements between pH 3.1 and 4.6 reported by van der Weijden and van Leeuwen (1985) lead to log K_d (ml/g) = −1.073 + 0.8218 pH (r = 0.993) for uranyl adsorption by peat. Andersson et al. (1982) have reported linear log K_d versus pH plots for Cs^+ and Sr^{2+} adsorption by a number of igneous rocks and minerals between pH 5 to 11.

When a contaminant species of interest is already present in the soil or groundwater, it is highly recommended that the water and soil be sampled and analyzed for the contaminant to determine an *in situ* K_d value. This is, after all, the K_d we are interested in. Its value often differs substantially from a K_d measured in the laboratory. For example, Fruchter et al. (1985) report respective laboratory K_d's of 3560, 400, and 19 ml/g for ^{60}Co, ^{106}Ru, and ^{125}Sb. Respective *in situ* K_d's for these radionuclides equaled 9, 6, and 4, indicating that, in fact, they were relatively mobile in the groundwater. The authors point out that the laboratory K_d's were measured in noncomplexing electrolyte solutions, whereas in the field the radionuclides were complexed, probably by organic substances, making them less likely to be adsorbed.

The best use of K_d is probably to model the sorption of trace molecular organic species such as pesticides, or other weakly sorbed nonionized organic species. The adsorption of dissolved molecular organic substances by soils and sediments has been found to be proportional to the amount of solid organic matter present and relatively independent of the weight of associated inorganic materials. This observation, which is particularly true in soils that contain 0.1 to 20% organic carbon (cf. Lyman et al. 1982; Thurman 1985; Schwarzenbach et al. 1993), has led to the concept of the adsorption or distribution coefficient for organic carbon or K_{oc} defined as

$$K_{oc} = \frac{\mu\text{g adsorbed/g organic C}}{\mu\text{g/ml in solution}} \tag{10.4}$$

The weight ratio of total organic matter to organic carbon ranges from about 2.0 in soil fulvic acids to 2.7 in humin (Schwarzenbach et al. 1993). Assuming average organic matter is approximately CH_2O, the weight ratio is 2.5. The distribution coefficient for organic substances sorbed by total organic matter (K_{om}) is then related to K_{oc} by $K_{oc} = 2.5 \times K_{om}$. Values of K_{oc} range from 1 to 10^7 ml/g of organic carbon. Example K_{oc} values (in ml/g) for some common organic contaminants, including pesticides, are: benzene, 83; atrazine, 160; lindane, 1080; malathion, 1800; parathion, 1.06×10^4; DDT, 2.43×10^5; and mirex, 2.4×10^7 (Lyman et al. 1982).

For organic sorbates, the distribution coefficient K_d is related to K_{oc} through the expression

$$K_d = K_{oc} \times f_{oc} \tag{10.5}$$

where f_{oc} is the weight fraction of organic carbon in the sediment. Frequently K_{oc} values have not been measured. K_{oc} is, however, related to other important properties of organic substances, includ-

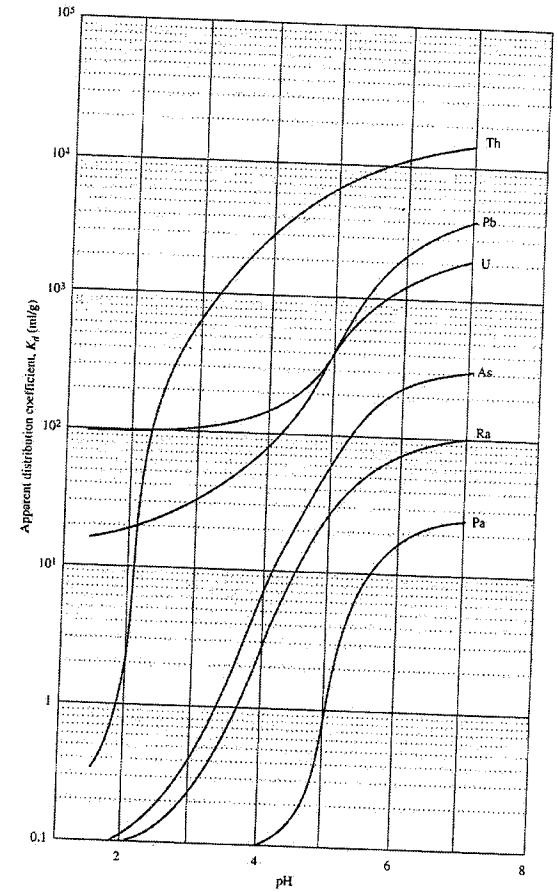

Figure 10.8 Lumped-process distribution coefficients (K_d's) for some elements measured during laboratory neutralization of acid solutions with calcium carbonate (Taylor 1979). These K_d values represent the combined effects of element removals by adsorption, coprecipitation, and/or precipitation onto and in freshly precipitated Fe(III), Al, and Mn(IV) oxyhydroxides and hydroxysulfates. As such they are system specific and cannot be assumed to apply to other systems under different conditions or having different compositions.

ferrous iron is released to solution. The stoichiometry of the oxidation half reaction (Eq. [12.34]) suggests that a mole of pyrite should produce 16 protons. However, only the complete oxidation reaction, which must include an oxidizing agent, can provide us with a valid reaction stoichiometry. Two possible overall redox reactions are

$$FeS_2 + \tfrac{7}{2}O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+ \tag{12.39a}$$

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+ \tag{12.39b}$$

Thus, if O_2 is the oxidizing agent, 2 moles of H^+ are produced by 1 mole of pyrite. In contrast, oxidation by Fe^{3+} releases 16 moles of protons for each mole of pyrite. Obviously, it is essential to know which reaction dominates in any attempt to predict the acid-generating capacity of a system.

The next step is the oxidation of ferrous to ferric iron. The rate of the Fe^{3+}/pyrite oxidation reaction is, in fact, limited by the availability of Fe^{3+}, which itself depends on the Fe(II) oxidation rate. Below about pH 3 the overall Fe(II) oxidation reaction is

$$Fe^{2+} + \tfrac{1}{4}O_2 + H^+ \rightarrow Fe^{3+} + \tfrac{1}{2}H_2O \tag{12.40}$$

The abiotic rate of this reaction is slow. The pH of streams and groundwaters that have moved away from source pyrite surfaces increases because of partial neutralization by carbonate and silicate minerals. Above roughly pH 3, Fe^{2+} oxidation is then described by the overall reaction

$$Fe^{2+} + \tfrac{1}{4}O_2 + \tfrac{5}{2}H_2O \rightarrow Fe(OH)_3 + 2H^+ \tag{12.41}$$

which has a rate that increases rapidly with increasing pH. (See kinetics Chap. 2.)

Abiotic oxidation kinetics of sulfur and Fe(II). The abiotic oxidation rates of pyrite and ferrous iron have been studied extensively for more than 30 years (cf. Garrels and Thompson 1960; McKibben and Barnes 1986; Nicholson et al. 1988; Moses and Herman 1991). The work on pyrite-oxidation kinetics has been updated and critiqued by Williamson and Rimstidt (1994), while Wehrli (1990) has synthesized the published data on Fe^{2+} oxidation. (See also King et al. 1995.)

Based on statistical analysis of published FeS_2 oxidation-rate data and their own work, Williamson and Rimstidt (1994) derived three empirical rate law expressions, where $r = d(FeS_2)/dt$ is the rate of pyrite destruction in mol/m^2 s. From pH 2 to 10 when oxygen is the only oxidant (as perhaps above the water table in spoil materials or coarse-grained tailings) the rate law is

$$r = (10^{-8.19})\frac{(mO_2)^{0.5}}{(mH^+)^{0.11}} \tag{12.42}$$

Between pH 0.5 to 3.0, when Fe^{3+} is the oxidant and oxygen is absent (conditions that might be expected in an acid groundwater or in flooded-mine pools), the rate equation is

$$r = (10^{-8.58})\frac{(mFe^{3+})^{0.30}}{(mFe^{2+})^{0.47}\,(mH^+)^{0.32}} \tag{12.43}$$

In the same acid pH range, when $O_2(aq)$ is present along with Fe^{3+}, the rate is given by

$$r = (10^{-6.07})\frac{(mFe^{3+})^{0.93}}{(mFe^{2+})^{0.40}} \tag{12.44}$$

The latter conditions might be found near a fluctuating water table or within the capillary zone above the water table. The success of Williamson and Rimstidt's model fits to published experimental data is evident from Fig. 12.20. Regardless of the oxidant, the pyrite breakdown rate is seen to be practi-

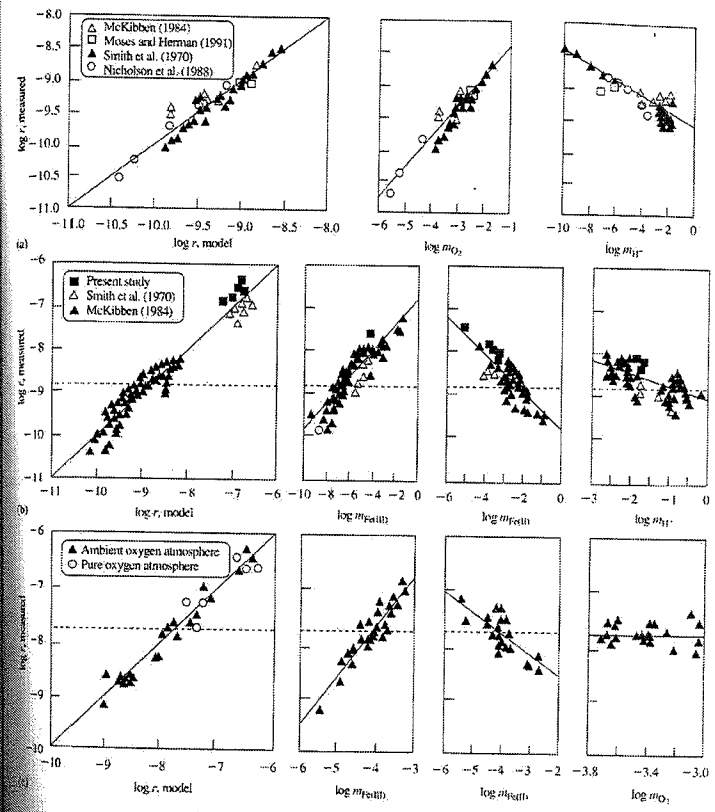

Figure 12.20 The rate of oxidation of pyrite ($r = d[FeS_2]/dt$ in mol/m^2 s) near 25°C and 1 bar pressure. Whole model and leverage plots for multiple linear regression analysis of published and measured rate data for the aqueous oxidation of pyrite: **(a)** Oxidation of pyrite by dissolved oxygen; **(b)** Oxidation of pyrite by ferric iron under an N_2 atmosphere; and **(c)** Oxidation of pyrite by ferric iron in the presence of dissolved oxygen. Reprinted from *Geochim. et Cosmochim. Acta*, 58, M. A. Williamson and J. D. Rimstidt, The kinetics and electrochemical rate-determining step of aqueous pyrite oxidation, 5443–54, © 1994, with permission from Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington OX5 1GB, U.K.

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SUBJECT TO TRIAL COURT DELAY REDUCTION ACT
FIRST CASE MANAGEMENT CONFERENCE: 11-23-98 @ 1:30 P.M.
ASSIGNED JUDGE: ROGER M. SETTLEMIRE

SUPERIOR COURT OF THE STATE OF CALIFORNIA

COUNTY OF PLUMAS

PEOPLE OF THE STATE OF CALIFORNIA, ex rel. CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, CENTRAL VALLEY REGION; and the STATE OF CALIFORNIA WATER RESOURCES CONTROL BOARD on behalf of the CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, CENTRAL VALLEY REGION, Plaintiffs, v. CEDAR POINT PROPERTIES, INC., a California Corporation; DANIEL R. KENNEDY, individually and as President of Cedar Point Properties, inc., and DOES I - XXX, Defendants.	Case No. 19897 COMPLAINT FOR INJUNCTIVE RELIEF FOR VIOLATION OF CLEANUP AND ABATEMENT ORDER; FOR MONEY JUDGMENT AND FORECLOSURE OF CLEANUP AND ABATEMENT ACCOUNT LIEN; OR IN THE ALTERNATIVE TO VOID FRAUDULENT TRANSFER; FOR INDIVIDUAL LIABILITY OF CORPORATE OFFICER; TO PIERCE CORPORATE VEIL; FOR INJUNCTIVE RELIEF TO ESCROW TIMBER HARVEST PROCEEDS; AND FOR CIVIL PENALTIES

PLAINTIFFS, People of the State of California, ex rel. California Regional Water Quality Control Board, Central Valley Region; and the State of California Water Resources Control Board on behalf of the California Regional Water Quality Control Board, Central Valley Region, allege as follows:

GENERAL ALLEGATIONS

1. This action is brought by the Attorney General at the request of the California Regional Water Quality Control Board, Central Valley Region, ("Regional Board"), and the State Water Resources Control Board ("SWRCB"), on behalf of the People of the State of California, as set forth in Water Code sections 13304(a),(c), 13361, 13385, and 13386.

2. The Regional Board is a state agency, and is part of the California Environmental Protection Agency. Cal. Water Code §§ 175, 13100. The Regional Board is one of nine created to establish and enforce water quality control plans to ensure the protection of beneficial uses of water within nine designated regions in the State of California. Cal. Water Code §§ 13200, 13201, 13240 et seq. The Central Valley Region "comprises all basins . . . draining into the Sacramento and San Joaquin Rivers to the easterly boundary of the San Francisco Bay region near Collinsville." Id. § 13200.

3. The Regional Board is charged with obtaining coordinated action in water quality control, including prevention and abatement of water pollution and nuisance, encouraging proper waste disposal, requiring state and local agency investigation and reports of water quality, and requesting enforcement of appropriate laws by other agencies within the Central Valley Region. Id. § 13225. To further these goals, the Regional Board

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has primary local enforcement authority including power to remedy unlawful discharges, and to achieve cleanup and abatement of unlawful water pollution. Id. § 13300 et seq.

4. The SWRCB is a state agency and is part of the California Environmental Protection Agency. Cal. Water Code §§ 175, 13100. The SWRCB is the designated state water pollution control agency for all purposes in the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.), and is the agency charged with administering California law regarding permits or licenses to appropriate water, and with formulating and adopting policy in the state for water quality control. Cal. Water Code §§ 179, 13100 et seq. The SWRCB oversees the nine Regional Water Quality Control Boards in their establishment and enforcement of water quality control plans, to ensure the protection of beneficial uses of water within the State of California. Id. §§ 13200, 13240 et seq.

5. Cedar Point Properties, Inc., is a California corporation, whose registered address is 800 Cynthia Lane, Paradise, CA 95969.

6. Documents on file with the State of California Office of the Secretary of State show that Cedar Point Properties, Inc.'s type of business is timber and logging.

7. Documents on file with the State of California Office of the Secretary of State show that Daniel R. Kennedy is the President and designated agent for service of process for Cedar Point Properties, Inc.

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8. Daniel R. Kennedy is named herein individually and in his capacity as President for Cedar Point Properties, based on his direct involvement in and responsibility for certain acts and omissions herein alleged.

9. The true names, capacities, and involvement herein of Does I through XXX, inclusive, whether corporate, individual, associate or otherwise, are unknown to Plaintiffs, who therefore sues said defendants by such fictitious names. Plaintiffs are informed and believes and thereon alleges that each of these fictitiously named defendants Does I through XXX, inclusive were agents, servants, or employees of their co-defendants, and in doing the things hereinafter alleged were acting in the scope of their authority as such agents, servants, or employees, and with the permission and consent of their co-defendants.

10. Any reference to "defendants," is to Cedar Point Properties, Inc., to Daniel R. Kennedy, individually and in his capacity as President of Cedar Point Properties, and to Does I through XXX, inclusive, equally. Plaintiffs will ask leave of court to amend this complaint to show the true names and capacities of Does fictitiously named herein when the same have been ascertained.

VENUE

11. Defendants own certain property located in Plumas County, California. Defendants under the laws of the State of California are obligated to prevent unlawful discharges of pollutants from their property into the waters of the State of California. Despite their legal obligation, Defendants have

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failed or refused to remedy unlawful discharges emanating from a condition of pollution and nuisance on their property, into the waters of the State of California.

12. The Regional Board at all times relevant to this action has performed legally authorized remediation, cleanup and abatement activities, in order to clean up, abate and remedy harmful discharges into the waters of the State of California from Defendants' property, in Plumas County.

13. The Regional Board has incurred and continues to incur reasonable costs, recoverable from Defendants, based on its remediation, clean up, and abatement activities on Defendants' property, in Plumas County.

14. Pursuant to California law, the Regional Board's reasonable costs constitute a lien on Defendants' property, which lien extends by law to all timber thereon. Civ. Code §§ 658, 660, Water Code § 13304.

15. The Plumas County Recorder recorded notice of the amount of said lien on or about March 13, 1998. This action in part seeks to reduce the amount of additional costs incurred to the date of filing this complaint to a money judgment, and to foreclose upon the lien of record.

16. Based on the foregoing, venue is appropriate in Plumas County.

FACTS COMMON TO ALL CAUSES OF ACTION

17. The Walker Mine is a 782-acre inactive copper mine. The Walker Mine is in central Plumas County about 24 miles north of Portola in Sections 19, 29, 30, 31, and 32, T25N, R12E, and in Sections 5,6,7, and 8, T24N, R12E, MDB& M. The Walker Mine

Property consists of Assessor's Parcel Numbers 009-080-01, 009-090-01, and 009-100-09.

18. Since Walker Mine's closure in 1941, the site has discharged acid and heavy metals into the Little Grizzly Creek watershed. There are three discharges from the Walker Mine Property. These identified discharges include the main portal, intermittent discharges from an unlined settling pond, and intermittent discharges of surface water runoff from waste piles.

19. The discharges from Walker Mine negatively impact the Little Grizzly Creek watershed, and cause a condition of pollution and nuisance. As a result, the Little Grizzly Creek watershed is listed as a water quality limited segment in the applicable Water Quality Control Plan. Beneficial uses of surface water are aquatic life, wildlife habitat, and recreation.

20. On or about May 9, 1997, the County of Plumas held a tax sale, where the Walker Mine Property was made available for purchase at public auction.

21. Prospective bidders at the May 9, 1997 tax sale, including Defendants, were provided written notice prepared by counsel for Plumas County, Robert Shulman, of the potential for "liability for clean-up of toxic waste." The notice referred to the Walker Mine Property by name and Assessor's Parcel Numbers, incorporated selected portions of relevant documents available to the public, and, where documents were recorded with the County Recorder's office, showed copies of the book and page number of recordation. The notice directed Defendants' attention to the need to diligently investigate the Walker Mine Property.

22. One document incorporated in part into the written

notice provided to prospective purchasers and Defendants was a judgment pursuant to stipulation, recorded in its entirety on May 7, 1997 by the Plumas County Recorder, at the request of the Regional Board.

23. Plaintiffs are informed and believe and thereon allege, that on or about May 9, 1997, at the public auction discussed in Paragraph 19, above, Daniel R. Kennedy purchased the Walker Mine Property.

24. Documents on file with the Office of the California Secretary of State indicate Cedar Point Properties, Inc.'s date of incorporation/qualification is August 19, 1997, and the filing date for its statement of officers is November 19, 1997.

25. Documents on file with the State of California Department of Corporations show that on or about March 2, 1998, Daniel R. Kennedy as President/CEO of Cedar Point Properties, Inc., filed a notice of issuance of stock, indicating that $25,000.00 in stock would issue to and be held by Daniel R. Kennedy and Andrew Cardin.

26. Plaintiffs are informed and believe based on the dates indicated in the documents discussed in Paragraph 23, above, that it was not until some time after May 9, 1997, that Daniel R. Kennedy or his agent filed documents with the Office of the California Secretary of State, in order to form Cedar Point Properties, Inc.

27. Documents on file with the Plumas County Recorder's Office show that tax deeds for the sale of the parcels comprising the Walker Mine Property were recorded in the Plumas County Recorder's office on or about September 8, 1997. The tax deeds

describe a sale on May 9, 1997, to Cedar Point Properties, Inc., as purchaser, and the Tax Collector of Plumas County as seller.

28. Plaintiffs are informed and believe and thereon allege that in September 1997, Daniel R. Kennedy submitted a Timber Harvest Plan ("THP") to the California Department of Forestry ("CDF"). The THP submitted proposes a harvest of timber from 560 acres of land in Plumas County. The THP was executed by Daniel R. Kennedy on September 25, 1997. On or about September 26, 1997, CDF assigned the THP number 2-97-323-PLU(2).

29. A portion of the location and legal description of land proposed to be harvested in THP No. 2-97-323-PLU(2) matches that of the Walker Mine Property.

30. THP No. 2-97-323-PLU(2) designates Daniel Kennedy as the Plan Submitter, and Timber Owner of Record, in his individual capacity, and was executed by Daniel Kennedy in that capacity.

31. THP No. 2-97-323-PLU(2) designates Cedar Point Properties, Inc., as the Timberland Owner of Record, and was executed in that regard by Daniel Kennedy on behalf of Cedar Point Properties "representing Cedar Point Properties as President."

32. California Water Code section 13304 provides in relevant part:

> (a) Any person who has discharged or discharges waste into the waters of this state in violation of any waste discharge requirement or other order or prohibition issued by a regional board or the state board, or who has caused or permitted, causes or permits, or threatens to cause or permit any waste to be discharged or deposited where it is, or probably will be, discharged into the waters of the state and creates, or threatens to create, a condition of pollution or nuisance, shall upon order of the regional board, clean up the waste or abate the effects of the waste, or, in the case of threatened pollution or nuisance, take

other necessary remedial action, including, but not limited to, overseeing cleanup and abatement efforts. Upon failure of any person to comply with the cleanup or abatement order, the Attorney General, at the request of the board, shall petition the superior court for that county for the issuance of an injunction requiring the person to comply with the order. In any such suit, the court shall have jurisdiction to grant a prohibitory or mandatory injunction, either preliminary or permanent, as the facts may warrant.

. . . .

(c)(1) If the waste is cleaned up or the effects of the waste are abated, or, in the case of threatened pollution or nuisance, other necessary remedial action is taken by any governmental agency, the person or persons who discharged the waste, discharges the waste, or threatened to cause or permit the discharge of the waste within the meaning of subdivision (a), are liable to that governmental agency to the extent of the reasonable costs actually incurred in cleaning up the waste, abating the effects of the waste, supervising cleanup or abatement activities, or taking other remedial action. The amount of the costs is recoverable in a civil action by, and paid to, the governmental agency and the state board to the extent of the latter's contribution to the cleanup costs from the State Water Pollution Cleanup and Abatement Account or other available funds.

(2) The amount of the costs constitutes a lien on the affected property upon service of a copy of the notice of lien on the owner and upon the recordation of a notice of lien, which identifies the property on which the condition was abated, the amount of the lien, and the owner of record of the property, in the office of the county recorder of the county in which the property is located. Upon recordation, the lien has the same force, effect, and priority as a judgment lien, except that it attaches only to the property posted and described in the notice of lien, and shall continue for 10 years from the time of the recording of the notice, unless sooner released or otherwise discharged. Not later than 45 days after receiving a notice of lien, the owner may petition the court for an order releasing the property from the lien or reducing the amount of the lien. In this court action, the governmental agency that incurred the cleanup costs shall establish that the costs were reasonable and necessary. The lien may be foreclosed by an action brought by the state board, on behalf of the regional board, for a money judgment. Money recovered by a judgment in favor of the state board shall be deposited in the State Water Pollution Cleanup and Abatement

Account.

. . . .

33. California Water Code section 13267 provides in relevant part:

> (a) A regional board, in establishing or reviewing any water quality control plan or waste discharge requirements, or in connection with any action relating to any plan or requirement or authorized by this division, may investigate the quality of any waters of the state within its region.
>
> (b)(1) In conducting an investigation specified in subdivision (a), the regional board may require that any person who has discharged, discharges, or is suspected of discharging , or who proposes to discharge waste within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of discharging , or who proposes to discharge, waste outside of its region that could affect the quality of waters within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the regional board requires. The burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the report.

. . . .

34. California Water Code section 13330 provides for review of Regional Board Orders appealed to the SWRCB, or for which the SWRCB declines to hear an appeal, by the Superior Courts of California upon petition for writ of mandate. That section provides in relevant part: "(c) If no aggrieved party petitions for writ of mandate within the time provided by this section, a decision or order of the state board or a regional board shall not be subject to review by any court."

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FIRST CAUSE OF ACTION
(For Injunctive Relief; Water Code § 13304)

35. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 34, inclusive, as though set forth in full herein.

36. On October 7, 1997, the Regional Board issued Cleanup and Abatement Order No. 97-715 to Cedar Point Properties, Inc., for the Walker Mine Property. Order No. 97-715 directs Cedar Point Properties, Inc., to 1) prevent additional releases of waste from the Walker Mine Property to surface waters, 2) provide continuous operations and maintenance of existing remedial structures, 3) complete specified tasks according to a designated time schedule, including submitting a completed National Pollutant Discharge Elimination System ("NPDES") permit application, providing technical reports, and implementing best management practices, 4) reimburse the Regional Board for reasonable costs associated with oversight and remedial activities, 5) grant reasonable site access to the Regional Board and its agents, 6) design and implement surface water diversions to minimize surface water runoff into Walker Mine, and 7) continue sampling, monitoring, and remediation efforts.

37. Defendants did not timely challenge Order No. 97-715 by way of administrative review before the SWRCB, or otherwise. Because no challenge to Order No. 97-715 was timely filed, the requirements of Order No. 97-715 are no longer subject to challenge.

38. To the date of this complaint, Defendants have failed to comply with any of the provisions of Order No. 97-715.

39. As a result of Defendants' failure to comply with Order No. 97-715, and pursuant to Water Code section 13304(a), the Regional Board has requested the Attorney General to seek the issuance of a preliminary and permanent injunction, and any other necessary relief, to require Defendants' compliance with the provisions of Order No. 97-715.

40. Wherefore, Plaintiffs pray that the Court enter a preliminary and permanent injunction directing Defendants to comply in all respects with Order No. 97-715, and establishing a reasonable schedule for such compliance which mirrors that set forth in said order.

SECOND CAUSE OF ACTION
(To Foreclose Cleanup and Abatement Account Lien, and For Monetary Judgment For Additional Costs Incurred to Date.)

41. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 40, inclusive, as though set forth in full herein.

42. In November 1987, pursuant to its remedial powers under the California Water Code, the Regional Board installed an engineered concrete mine seal in the Walker Mine. The seal prevents direct discharge of acid mine drainage from the mine's underground ore zone to surface waters.

43. Since the 1980's the Regional Board has maintained the mine seal and other remedial structures at Walker Mine. The seal must be continually monitored for leakage, hydrostatic pressure, and its effectiveness in preventing surface water pollution.

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44. Before and after purchasing the Walker Mine Property, Defendants have had actual or constructive knowledge of the Regional Board's activities on the Walker Mine Property, and that those activities would subject any owner of the Walker Mine Property to liability for the Regional Board's reasonable costs.

45. Before and after purchasing the Walker Mine Property, Defendants have had actual or constructive knowledge of the Regional Board's activities on the Walker Mine Property, and that a lien attached to the Walker Mine Property for the Regional Board's reasonable costs.

46. As of March 13, 1998, the Regional Board had incurred $238,334 in reasonable, reimbursable costs by way of its remediation, clean up, and abatement activities at the Walker Mine.

47. On March 13, 1998, at the request of the SWRCB, the Plumas County Recorder recorded a notice of lien in the amount of $238,334, describing the lien as attaching to the Walker Mine Property and including timber harvestable for commercial purposes.

48. The notice informed Defendants that in order to release the lien the owner of record of the property described in the lien must file a petition in the appropriate court of law no later than 45 days from the date of receipt of the notice.

49. The recorded notice was served by way of mail on Cedar Point Properties, Inc. at its registered address on March 17, 1998. Defendants did not timely file any petition challenging the lien.

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50. As of the date of filing this complaint, the Regional Board has incurred additional reasonable costs by way of its clean up, remediation, and abatement activities on the Walker Mine Property, over and above the $238,334 recorded in the March 13, 1998 notice of lien.

51. California Water Code, section 13304(c)(1) entitles Plaintiffs to a money judgment against Defendants for recovery of the amount of the Regional Board's additional reasonable costs to date.

52. California Water Code, section 13304(c)(2) entitles Plaintiffs to foreclose the lien of record described above for the amount of costs incurred to March 13, 1998, in this action.

53. Wherefore, Plaintiffs pray that the Court enter judgment against Defendants and for Plaintiffs in the amount of the Regional Board's additional reasonable costs to date, (which shall be subject to proof), and order that the lien of record may be foreclosed by Plaintiffs or, in the alternative, by a receiver appointed for such purpose.

THIRD CAUSE OF ACTION
(In the Alternative, to Void Fraudulent Transfer; Civ. Code § 3439.07)

54. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 53, inclusive, as though set forth in full herein.

55. Civil Code section 3439.01 provides in relevant part:

> (a) "Asset" means property of a debtor, but the term does not include, the following: (1) Property to the extent it is encumbered by a valid lien. . . .
> (b) "Claim" means a right to payment, whether or not the right is reduced to judgment, liquidated, unliquidated, fixed, contingent, matured, unmatured, disputed, undisputed, legal, equitable, secured, or unsecured.

(c) "Creditor" means a person who has a claim . . . .
(d) "Debt" means liability on a claim.
(e) "Debtor" means a person who is liable on a claim.
. . . .
(g) "Person" means an individual, . . . corporation .
. . .
(h) "Property" means anything that may be the subject of ownership.
(i) "Transfer" means every mode, direct or indirect, absolute or conditional, voluntary or involuntary, of disposing of or parting with an asset or an interest in an asset, and includes payment of money, release, lease, and creation of a lien or other encumbrance.

56. If the Court finds that Plaintiffs' lien for the Regional Board's reasonable costs incurred to date, described more fully above, does not extend to the rights in timber on the Walker Mine Property, based on an assignment of timber rights by Defendants or otherwise, Plaintiffs' reasonable costs incurred to date constitute a "claim" against Defendants, and Plaintiffs are "creditors" of Defendants, entitled to reach the timber rights by way of voiding said transfer.

57. Civil Code section 3439.04 provides that a transfer of property made or obligation incurred by a debtor is fraudulent as to a creditor where the debtor made the transfer or incurred the obligation "(a) With actual intent to hinder, delay, or defraud any creditor of the debtor," or "(b) Without receiving a reasonably equivalent value in exchange for the transfer or obligation," and the debtor reasonably should have believed that he or she would incur debts beyond his or her ability to pay as they became due.

58. Plaintiffs are informed and believe and thereon allege that Defendants caused transfers of certain property of value, including the rights to timber on the Walker Mine

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Property, with the intent to fraudulently hinder, delay, and avoid payment of Plaintiffs' claim against Defendants.

59. Plaintiffs are informed and believe and thereon allege that at the time said transfers were made, Defendants were insolvent, and that said transfers were made for inadequate consideration.

60. Civil Code section 3439.07 provides in relevant part:

> (a) In an action for relief against a transfer or obligation under this chapter, a creditor, subject to the limitations in Section 3439.08, may obtain:
> (1) Avoidance of the transfer or obligation to the extent necessary to satisfy the creditor's claim.
> (2) An attachment or other provisional remedy against the asset transferred or its proceeds in accordance with the procedures described in Title 6.5 (commencing with Section 481.010) of Part 2 of the Code of Civil Procedure.
> (3) Subject to applicable principles of equity and in accordance with applicable rules of civil procedure, the following:
> (A) An injunction against further disposition by the debtor or a transferee, or both, of the asset transferred or its proceeds.
> (B) Appointment of a receiver to take charge of the asset transferred or its proceeds.
> (C) Any other relief the circumstances may require.
> (b) If a creditor has commenced an action on a claim against the debtor, the creditor may attach the asset transferred or its proceeds if the remedy of attachment is available in the action under applicable law and the property is subject to attachment in the hands of the transferee under applicable law.
> (c) If a creditor has obtained a judgment on a claim against the debtor, the creditor may levy execution on the asset transferred or its proceeds.
> . . . .

61. Plaintiffs are entitled to an order voiding said transfer, and any other transfers of property made in violation of the Uniform Fraudulent Transfer Act, appointment of a receiver to take charge of the property and/or the timber harvest, and other such orders as may be necessary to secure the money owing the Plaintiffs for recovery of reasonable costs.

FOURTH CAUSE OF ACTION
(For Personal Liability of Corporate Officer)

62. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 61, inclusive, as though set forth in full herein.

63. Plaintiffs are informed and believe and thereon allege that as President of Cedar Point Properties, Inc., Daniel R. Kennedy was and is an agent of his corporate principal and a policy-maker who directs and ultimately controls said corporation's conduct.

64. Plaintiffs are informed and believe and thereon allege that as President of Cedar Point Properties, Inc., Daniel R. Kennedy personally participates in all decisions affecting actions taken by Cedar Point Properties, Inc.

65. Plaintiffs are informed and believe and thereon allege, Daniel R. Kennedy at all times relevant herein has been, and continues to be aware of the responsibility of Cedar Point Properties, Inc., to remedy the condition of pollution and nuisance emanating from and existing upon the Walker Mine Property.

66. Daniel R. Kennedy has negligently or intentionally failed to remedy the condition of pollution and nuisance on the Walker Mine Property.

67. Plaintiffs are informed and believe and thereon allege that Daniel R. Kennedy made transfers of assets which belonged to Cedar Point Properties, Inc., which transfers benefitted him personally, and which hindered Cedar Point Properties, Inc.'s ability to clean up, remedy, and abate the

condition of pollution and nuisance on the Walker Mine Property, and to meet its monetary obligation to Plaintiffs.

68. Wherefore Plaintiffs pray that the Court enter an order finding Daniel R. Kennedy personally liable for the acts and omissions in violation of the California Water Code, and for the debt to the Plaintiffs alleged herein, by way of his direct involvement in and responsibility for said acts and omissions.

FIFTH CAUSE OF ACTION
(In the Alternative, To Pierce the Corporate Veil and Impose Personal Liability)

69. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 68, inclusive, as though set forth in full herein.

70. Plaintiffs are informed and believe and thereon allege that Cedar Point Properties, Inc., operates as an "alter ego" of Daniel R. Kennedy.

71. Plaintiffs are informed and believe and thereon allege that Daniel R. Kennedy commingled corporate and noncorporate assets, diverted corporate resources to his own personal use and failed to keep an arms length relationship with Cedar Point Properties, Inc.

72. Plaintiffs are informed and believe and thereon allege that Defendants failed to observe certain corporate formalities.

73. Plaintiffs are informed and believe and thereon allege that Daniel R. Kennedy failed or refused to ensure that Cedar Point Properties, Inc., was and remains adequately funded to meet its debts and its responsibilities under the California Water Code and Order No. 97-715.

74. Plaintiffs are informed and believe and thereon allege, that Daniel R. Kennedy formed Cedar Point Properties, Inc., to accomplish the fraudulent goal of insulating himself from any liability arising from the Regional Board's remediation, clean up, and abatement costs, and from the requirements of the California Water Code, while personally benefitting from assignment of the Walker Mine Property's major asset, i.e. the timber rights.

75. Wherefore Plaintiffs pray the Court enter an order finding that Cedar Point Properties, Inc., is an "alter ego" of Daniel R. Kennedy, piercing the corporate veil, and rendering Daniel R. Kennedy personally liable for the debts, acts, and omissions of Cedar Point Properties, Inc., described herein, and for any judgment entered herein.

SIXTH CAUSE OF ACTION

(For Injunctive Relief Ordering Escrow of Timber Proceeds)

76. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 75, inclusive, as though set forth in full herein.

77. Plaintiffs are informed and believe and thereon allege that Defendants intend to begin harvesting timber under THP No. 2-97-323-PLU(2) as soon as practicable.

78. Based on the facts alleged herein, Plaintiffs are entitled to some or all of the proceeds of the timber harvest under THP No. 2-97-323-PLU(2).

79. Plaintiffs are informed and believe and thereon allege that absent provisional equitable relief, Defendants will simply harvest the timber on the Walker Mine Property, and

thereafter fail and refuse to perform required cleanup, remediation, and abatement of the condition of pollution and nuisance on the Walker Mine Property.

80. Plaintiffs will have no adequate remedy if Defendants are allowed remove the timber from the Walker Mine Property, obtain, and transfer the profits therefrom unsupervised by the Court.

81. Wherefore, Plaintiffs request that the Court issue a preliminary injunction ordering Defendants to disclose the mill where they plan to deliver harvested timber, and fashion an order to be served on said mill directing that all proceeds from timber harvested by Defendants under THP No. 2-97-323-PLU(2) be paid directly into an escrow account with the Court, set up for that purpose; that Defendants make a demand on that account for their reasonable costs associated with the harvest, and that Plaintiffs have a reasonable time thereafter to challenge the reasonableness of any such demand; that the remainder of said proceeds be applied to satisfy Plaintiffs' reasonable costs to date, and thereafter be applied to Defendants' performance of clean up, remediation, and abatement efforts on the Walker Mine Property according to the requirements of Order No. 97-715.

SEVENTH CAUSE OF ACTION
(For Civil Penalties and Injunctive Relief;
Water Code §§ 13385, 13386)

82. Plaintiffs repeat and reallege each and every matter of fact and allegation in Paragraphs 1 through 81, inclusive, as though set forth in full herein.

83. California Water Code section 13260 requires any person "discharging waste or proposing to discharge waste within

any region that could affect the quality of the waters of the state within any region," to file a "report of the discharge, containing . . . information which may be required by the board . . . ."

84. California Water Code section 13376 provides in relevant part that any person "discharging pollutants . . . to the navigable waters of the United States within the jurisdiction of this state" must file a report as set forth in section 13260.

85. California Water Code section 13385 provides in relevant part:

> (a) Any person who violates any of the following shall be liable civilly in accordance with subdivisions (b), (c), (d), (e), and (f):
> (1) Section . . . 13376.
> . . . .
> (4) Any order or prohibition issued pursuant to Section 13243 or Article 1 (commencing with Section 13300) of Chapter 5, if the activity subject to the order or prohibition is subject to regulation under this chapter.
> . . . .
> (b) Civil liability may be imposed by the superior court in an amount not to exceed the sum of both of the following:
> (1) Twenty-five thousand dollars ($25,000) for each day in which the violation occurs.
> (2) Where there is a discharge, any portion of which is not susceptible to cleanup or is not cleaned up, and the volume discharged but not cleaned up exceeds 1,000 gallons, an additional liability not to exceed twenty-five dollars ($25) times the number of gallons by which the volume discharged but not cleaned up exceeds 1,000 gallons.
> The Attorney General, upon request of a regional board or the state board, shall petition the superior court to impose the liability.
> . . . .

86. California Water Code section 13386 provides in relevant part:

> upon any threatened or continuing violation of any of the requirements listed in paragraphs (1) to (6), inclusive, of subdivision(a) of section 13385, . . . the Attorney General, upon the request of the state or

> regional board shall petition the appropriate court for the issuance of a preliminary or permanent injunction, or both, as appropriate, restraining that person or persons from committing or continuing the violation. Subdivision (b) of section 13331 shall be applicable to proceedings under this section.

87. The California Water Code requires Defendants to procure waste discharge requirements for the discharge of pollutants from the Walker Mine Property. Order No. 97-715 directs Defendants to submit a completed application for a NPDES permit by not later than April 1, 1998.

88. As of the date of this complaint, Defendants have not submitted a complete NPDES application to the Regional Board.

89. As a result of Defendants' failure to timely procure an NPDES permit, or to otherwise comply with Order No. 97-715, and the continued unlawful discharges from the Walker Mine Property; and pursuant to Water Code sections 13385 and 13386, the Regional Board has requested the Attorney General to seek civil penalties and the issuance of a preliminary and permanent injunction, and any other necessary relief.

90. Wherefore, Plaintiffs ask that the Court issue a preliminary and permanent injunction requiring Defendants to submit a completed NPDES permit application and to implement the requirements of Order No. 97-715 to remedy the unlawful discharges from the Walker Mine Property. Plaintiffs ask the Court to impose civil penalties on an

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4. An order stating that the lien of record extends to the timber on the Walker Mine Property, and that said lien may be foreclosed by Plaintiffs or by a receiver appointed by the Court, to satisfy the $238,334 due and owing to Plaintiffs; or, in the alternative, voiding any transfer of timber rights from Cedar Point Properties, Inc. to Daniel R. Kennedy or third parties, and entering a money judgment against Defendants in the amount of $238,334;

5. An order holding Daniel R. Kennedy personally liable for any judgment entered herein, and for compliance with Order No. 97-715 based on his acts and omissions as President of Cedar Point Properties; or, in the alternative, an order piercing the corporate veil, finding Cedar Point Properties, Inc. is the "alter ego" of Daniel R. Kennedy, and holding Daniel R. Kennedy personally liable for any judgment herein and for Cedar Point Properties, Inc.'s debts, acts, and omissions herein;

6. An order imposing civil penalties on Defendants for each day of violation of the requirement to procure an NPDES permit and remedy their unlawful discharges as set forth in Order No. 97-715, beginning from April 1, 1998, and continuing until Defendants submit a complete NPDES permit;

7. An Order awarding Plaintiffs their reasonable attorney fees incurred herein as reasonable and necessary costs incurred by Plaintiffs under Water Code section 13304;

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8. Such other and further relief as the Court deems just and proper.

DATED: July 2, 1998

Respectfully Submitted,

DANIEL E. LUNGREN
Attorney General
CHARLES W. GETZ, IV
Assistant Attorney General
RICHARD M. THALHAMMER
Supervising Deputy Attorney General

TRACY L. KNORR,
Deputy Attorney General
Attorneys for Plaintiffs

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

5 May 1999

DISCHARGER: Walker Mine

LOCATION & COUNTY: Plumas County

INSPECTION DATES: 28 April 1999

INSPECTED BY: Patrick Morris PWM

ACCOMPANIED BY: Emmit (snowmobile guide)

OBSERVATIONS AND COMMENTS:

The purpose of this inspection was to determine the status of the mine seal pressure recording equipment and to observe the subsidence areas above the mine workings.

The areas in front of portal and the waste piles were covered with 2-3 feet of snow. Snow drifts along the road leading to the portal were about 4-5 feet deep. The shed at the portal door kept snow from accumulating against the door and was easily accessible (no snow removal required). The door itself continues to be difficult to open and requires work (grinding the top edge) for easier access. I may work on this problem this summer when the generator is available to provide electricity for powertools.

The pressure recording equipment was properly functioning; the pressure head measured 62.5 psig (144 feet of head). The last 6 months of data were downloaded to the laptop computer. The voltage of the storage batteries measured 19.9 VDC, with pairs of batteries measuring 8.5 VDC (batteries B and D) and 11.4 VDC (batteries A and C) respectively. Batteries B and D have low voltage but are currently within an acceptable voltage range and should last until I replace them in June. The portal was then secured.

I collected surface water samples from 4 locations near the portal: the portal discharge (5-10 gpm), Dolly Creek upstream and downstream, and the settling pond. Snow and ice were covering the settling pond therefore I attempted to collect a sample below the ice. Due to the snow and ice, the analytical results from this sample may not be representative of the settling pond constituent concentrations. Sample results are pending.

The snow was much deeper at the Central Area and Piute Area sinkholes. The sinkholes contained snow that appeared to be 8-12 or more feet deep (it was to the lower branches of pine trees growing within the sinkholes). I did not observe the Middle Branch Ward Creek flowing into the Piute sinkholes due to the snow depth. I will reinspect these areas in June to estimate the flow into the sinkholes.

CONCLUSION:

The pressure recording equipment was functioning property and it should capture this spring's runoff event. I will revisit the site in June to replace the batteries, inspect the seal, collect water samples from all monitoring points, and further assess runoff into the subsidence areas.

Approved:		

State of California

The Resources Agency

Memorandum

Date : JUN - 7 1999

To : Jack Del Conte, Supervising Engineer
Central Valley Regional Water Quality Control Board
3443 Routier Road, Suite A
Sacramento, California 95827-3003

From : **Department of Water Resources**

Subject : Walker Mine

On our meeting of April 13th, we discussed several issues related to our Interagency Agreement for Walker Mine. It was determined that the Division of Engineering of the Department of Water Resources will be unable to perform the work detailed in your Agreement with the Division of Planning and Local Assistance, Northern District. We regret any delay or inconvenience that has occurred as a result of this misunderstanding. The Department of Water Resources is generally not experienced in mine engineering, however, we are able to provide several ideas to the CVRWQCB for this project based on our experience with hydraulic structures, tunnels and through our research of this problem. Please note that this information is preliminary in nature and is being provided to CVRWQCB for its consideration to assist in formulating a solution to the Walker Mine problem in conjunction with the engineering and construction entities CVRWQCB ultimately selects for this work.

DOE staff has researched the current mining industry practices and experiences related to the issues of acid mine drainage (AMD), the design and performance of concrete mine plugs in acidic environments and the specific conditions of Walker Mine. Staff has contacted numerous experts with extensive experience in mining engineering, concrete plug design, concrete plug construction, AMD treatment facilities and the consultants (SRK) who designed the bulkhead seal at Walker Mine. DOE staff has also reviewed the Walker Mine feasibility reports, design reports, plans, specifications, construction reports and other materials supplied by CVRWQCB staff and from SRK. Additionally, staff has reviewed abstracts from John F. Abel, Jr., Ph.D., a mining engineer and international consultant with design experience on dozens of concrete bulkheads similar to that used in Walker Mine. The results of this research indicate that the approach to the problem, as directed in the Interagency Agreement, may not meet the needs of the Regional Board and could not be completed within the established budget.

Based on the results of the research described above, several assumptions implied in the Interagency Agreement should be revisited, specifically, the design life of the plug, seepage around the plug and the ability of the mine to contain future inflow.

- The work plan referenced in the Interagency Agreement focuses on evaluating the condition of the concrete plug by means of non-destructive testing and core sampling. Failures of the concrete itself are extremely rare using the design methods chosen by SRK, as long as good concrete mix design and proper quality control were employed during construction. However, several mine seals have failed due to shearing or erosion of the surrounding rock, due to poor quality control during placement of the concrete, or due to inadequate grouting of the plug-rock interface. Mine plugs recently installed in several Colorado mines were designed using similar methods and are based on a 30-year design life. With proper maintenance, these plugs are likely to exceed the design life, however, they are not seen as a stand alone long-term solution. Most plugs installed in the last few years are typically part of a comprehensive AMD treatment program where the plug outlet is used to regulate system flow.

- It is extremely difficult to completely eliminate seepage when a concrete plug is exposed to significant hydrostatic loading, especially through fractures in the host rock and at the rock-plug interface. Recent data from the Walker Mine seal show a pressure head of over 200', which is one of the largest hydrostatic loads on any mine bulkhead in California. Minor seepage around the plug should be expected, monitored and correlated with the water surface elevation behind the plug. Since it would be very difficult and expensive to eliminate seepage, any future grouting program should have specific criteria to minimize seepage based on a predetermined acceptable rate.

- The ability of the mine to contain the AMD is based on an assumption that a state of equilibrium will develop where annual inflow is balanced by discharge to a deep groundwater system. The water surface elevation in Walker mine is rising, and if it continues to rise, it will eventually discharge out of the Piute Shaft Landing Tunnel at elevation 6,585 feet (approximately 385 feet above the plug) and ultimately into the Middle Fork of Ward Creek. Unfortunately, consistent water surface elevation data is not available due to technical difficulties and vandalism to the existing monitoring system. The available data show that the pressure head was around 75-100 feet in the early 1990s and around 150-200 feet since 1997. The water surface elevation in the

mine fluctuates seasonally and can rise 75 feet or more in one year. Under current conditions, AMD could begin discharging from the Piute Shaft Landing Tunnel after two consecutive wet years. Additionally, as the water surface elevation rises within the mine, it becomes increasingly likely that AMD will begin appearing in springs, seeps and fractures around the mountain, as witnessed in other similarly sealed mines.

The terms of the Interagency Agreement cite an assumed design life of 100 years for the concrete plug, that seepage can be stopped with grouting and that the mine will continue to contain the AMD in a state of equilibrium. For technical, financial and liability reasons, DOE is unwilling to undertake engineering and construction responsibilities for such a project. Additional preliminary and generalized observations by DOE, which CVRWQCB should explore further with its selected engineering and construction entities, include the following:

1. Develop an Effective Seepage Monitoring System. This will require sealing the floor of the mine at the bulkhead invert and creating a small reservoir to separate and measure the flows through the bottom, top and sides of the plug area. The results should be correlated with measured pressure head. Additionally, quarterly monitoring of the area around the mine should be conducted to visually inspect for new seeps or springs, as recommended by SRK in the Feasibility and Design Report, September 1985, Section 4.2. The water surface elevation should also be recorded from the existing monitoring well in addition to the data collected from the pressure system located in the plug face.

2. Minimize the Inflow to the Mine. The diversion ditches should be maintained and expanded as necessary. The subsidence areas may need to be graded or capped in order to minimize intrusion. If these efforts are successful, then a state of equilibrium may be achievable within the mine, thereby lowering pressure head and minimizing seepage. Additionally, rain and runoff should be monitored in order to determine the effectiveness of the diversion system, as recommended by SRK in the Feasibility and Design Report, Section 4.3.

3. Begin Permitting and Design for an AMD Treatment Facility. This recommendation was included in the SRK Feasibility and Design Report, Section 5.3, Item 6, as "... a contingency plan to relieve any excess build up of water that might threaten to overflow out of the Piute Shaft." Passive

treatment designs have progressed enormously since this 1985 report and it is now very common to utilize adit bulkheads as part of a comprehensive treatment program. In addition to providing an emergency contingency plan, a treatment facility would allow the water surface elevation in the mine to be lowered, reducing the pressure head, decreasing the rate of seepage and improving the safety of future grouting around the plug. If inflow is adequately controlled to establish an acceptable equilibrium, then the treatment system may never need to be utilized. However, due to the limited reaction time that may occur from either a discharge out of Piute Shaft or a sudden development of significant outflow, it would be prudent to have permits and a design in place for prompt construction of a treatment facility.

4. Improve Security to Prevent Vandalism. The Walker Mine portal has been vandalized and breached with damage to the steel access door and theft of monitoring equipment. A similar incident could result in opening of a valve with a resulting uncontrolled release of AMD out of the portal. DOE recommends installation of a security fence around the portal and maintenance of the steel access door and frame.

Although DOE was not able to perform the engineering and construction work, as described in the Interagency Agreement, we hope that the preliminary information and observations noted above are helpful to the CVRWQCB.

If you have any questions, please call me at (916) 653-7542 or Ron Lee at (916) 653-6846.

Sincerely,

Raphael A. Torres

Raphael A. Torres, Chief
Civil Engineering Branch
Division of Engineering

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO. 99-110

NPDES NO. CA0084531

WASTE DISCHARGE REQUIREMENTS FOR CEDAR POINT PROPERTIES, INC. WALKER MINE PLUMAS COUNTY

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Board) finds that:

1. Cedar Point Properties, Inc., (hereafter Discharger), submitted a Report of Waste Discharge, dated 30 March 1998, and applied for a permit to discharge waste under the National Pollutant Discharge Elimination System (NPDES) from the Walker Mine, Plumas County.

2. The Report of Waste Discharge was deemed incomplete and the Discharger was notified by letter, dated 23 April 1998, of the need for additional information. Items requested from the Discharger include a description of its ownership arrangement (corporation, private owner, etc.); the names of the corporate officers, partners, or owners as applicable; if a corporation, certification of registration with the Secretary of State to conduct business in California; and a $10,000 filing fee. The information and filing fee were never received.

3. The Walker Mine was previously owned by the Calicopia Corporation and discharges from the mine were regulated under waste discharge requirements Order No. 90-030 (NPDES No. CA0080110) adopted by the Board on 26 January 1990. Cedar Point Properties, Inc., purchased the property in August 1997.

4. On 7 October 1997, the Executive Officer issued Cleanup and Abatement Order No. 97-715 requiring, in part, that the Discharger prevent additional releases of waste to surface waters; provide continuous operations and maintenance of existing remedial structures; submit a completed application of an NPDES permit; propose and implement a plan to minimize waste discharges from the mine tailings and sediment pond; implement surface water diversions to minimize infiltration into the mine workings; and monitor surface water in the surrounding watersheds. As of 1 June 1999, the Discharger has failed to comply with any of the requirements of the Cleanup and Abatement Order.

5. The Walker Mine is in east central Plumas County about 24 miles north of Portola, in Sections 19, 29, 30, 31, and 32, T25N, R12E, and Sections 5, 6, 7, and 8, T24N, R12E, MDB&M, as shown on Attachment A, which is incorporated herein and made a part of

this Order. The properties comprise of Plumas County Assessor Parcel Nos. 009-090-01, 009-080-01 and 009-100-09, and represent approximately 782 acres.

6. Mining operations ceased in 1941; however, waste constituents in the form of acid mine drainage (AMD) have entered the Dolly Creek watershed. The nonoperating mine continues to discharge AMD from a portal, sediment pond, and waste rock piles. The discharge from the mine enters Dolly Creek, which flows into Little Grizzly Creek, which in turn is tributary to Indian Creek and the East Branch, North Fork Feather River. The point source discharges to surface waters are designated as follows:

Source	Discharge Point	Discharge Identification Number
Main Portal	Drainage to Dolly Creek	001
Sediment Pond	Drainage to Dolly Creek	002
Waste Rock Piles	Drainage to Dolly Creek	003

7. Rainwater infiltrates into the mine workings through soil, rock, and subsidence areas above the mine. This water contacts sulfide deposits open to air in the old tunnel complexes of the mine. The ensuing chemical reaction significantly lowers the pH of the water. As this water moves out of the mine tunnels, its acidic nature leaches metals from the rocks. The discharge, referred to as AMD, is toxic to fish and other aquatic organisms.

8. In November 1987, pursuant to its cleanup and abatement authority, the Board completed construction of a mine seal in the main 700 level access tunnel of the mine, 2,675 feet from the entrance portal. While the discharges of AMD have been significantly reduced, AMD from the main portal, a sediment pond below the portal, and waste rock piles continues to enter the Dolly Creek drainage and impact beneficial uses.

9. Discharges of AMD from other point and nonpoint sources on the property may include, but are not limited to, unknown or buried portals, seeps, exposed ore and mineral zones, and mine waste dumps.

10. Inspections conducted by Regional Board staff since 1987 have confirmed discharges from the mine portal, sediment pond, and the waste rock piles. The discharges from the mine portal and sediment pond are characterized, based on sampling conducted over the past 10 years, as follows:

	Main Portal 001	Sediment Pond[1] 002
Flow (gpm)	4.5	--
Copper		
µg/l	303	1250
lbs/day	0.015	--
Zinc		
µg/l	25	170
lbs/day	0.0013	--
pH	6.6 - 9.1	7.7 - 8.7

[1] Based upon limited data.

11. The continued unabated or untreated discharge of AMD from these sources will constitute a violation of this permit. A cease and desist order, proposed concurrently with this permit, contains a reasonable time schedule for achieving compliance with all Prohibitions, Specifications, and Limitations specified in this Order.

12. The Board adopted a Water Quality Control Plan, Fourth Edition, for the Sacramento River Basin and the San Joaquin River Basin, (hereafter Basin Plan) which designates beneficial uses, establishes water quality objectives, and describes an implementation program and policies to achieve those objectives for all waters of the Basin. These requirements implement the Basin Plan.

13. Federal regulations require effluent limitations for all pollutants that are or may be discharged at a level that will cause or have the reasonable potential to cause, or contribute to an in-stream excursion above a narrative or numerical water quality standard. Based on information submitted as part of the application, in studies, and as directed by monitoring and reporting programs, the Board finds that the discharge does have a reasonable potential to cause or contribute to an in-stream excursion above a water quality objectives for copper, zinc, and total suspended solids. Effluent limitations for these constituents are included in this Order.

14. The beneficial uses of the North Fork, Feather River are municipal and domestic supply, power generation, recreation, preservation and enhancement of cold-water fisheries and spawning habitat (aquatic life), and wildlife.

15. The Basin Plan states that the beneficial uses of any specifically identified water body generally apply to its tributary streams. Existing and potential beneficial uses of Dolly

Creek and Little Grizzly Creek, tributaries to North Fork, Feather River, include recreation, preservation and enhancement of cold water fisheries and spawning habitat (aquatic life), and wildlife. Historically, prior to impacts to the watercourses from mining, Dolly Creek and Little Grizzly Creek were considered a prime cold-water fishery. The watercourses are currently utilized for recreation and preservation and enhancement of wildlife. The Basin Plan also lists Dolly Creek and Little Grizzly Creek as Water Quality Limited Segments for aquatic life downstream of the Walker Mine.

16. The permitted discharge is consistent with the anti-degradation provisions of 40 CFR 131.12 and State Water Resources Control Board Resolution 68-16. The impact on existing water quality will be insignificant.

17. Effluent limitations and toxic and pretreatment effluent standards established pursuant to Sections 301, 302, 304, and 307 of the Clean Water Act (CWA) and amendments thereto are applicable to the discharge.

18. The facility is not subject to a federal stormwater permit at this time. However, stormwater discharges from the facility are covered under this permit.

19. The action to adopt an NPDES permit is exempt from the provisions of Chapter 3 of the California Environmental Quality Act (CEQA) (Public Resources Code Section 21100, et seq.), in accordance with Section 13389 of the California Water Code.

20. The Board has notified the Discharger and interested agencies and persons of its intent to prescribe waste discharge requirements for this discharge and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations.

21. The Board, in a public meeting, heard and considered all comments pertaining to the discharge.

22. This Order shall serve as an NPDES permit pursuant to Section 402 of the CWA, and amendments thereto, and shall take effect upon the date of hearing, provided U.S. Environmental Protection Agency (USEPA) has no objections.

IT IS HEREBY ORDERED that Order No. 90-030 is rescinded and Cedar Point Properties, Inc., its agents, successors, and assigns, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, and the provisions of the CWA and regulations and guidelines adopted thereunder, shall comply with the following:

A. Discharge Prohibitions:

1. By-pass or overflow of untreated or partially treated AMD is prohibited.

B. Effluent Limits (Discharge 001, 002, and 003)

1. The discharge of treated AMD in excess of the following limits is prohibited:

Parameter	Unit	30-Day Average	Daily Maximum
Copper	µg/l	150	300
Zinc	µg/l	750	1500
Cadmium	µg/l	50	100
Mercury	µg/l	1	2
Lead	µg/l	300	600
Total Suspended Solids	mg/l	20	30

2. Survival of test fish in 96-hour bioassays of undiluted waste shall be no less than:

   Minimum for any one bioassay - 70%
   Median for any three or more consecutive bioassays - - - - - - 90%

3. The Discharger shall not use dilution as a means for compliance with effluent limits.

C. Discharge Specifications

1. Neither the treatment nor the discharge shall cause a pollution or nuisance as defined by the California Water Code, Section 13050.

2. The discharge shall not cause degradation of any water supply.

3. Stormwater discharges to any surface or groundwater shall not adversely impact human health or the environment.

4. Stormwater discharges shall not cause or contribute to a violation of any applicable water quality standards contained in the Basin Plan.

D. Receiving Water Limitations

Receiving water limitations are based upon water quality objectives contained in the Basin Plan. As such, they are a required part of this permit.

The discharge shall not cause the following in Dolly Creek:

1. Receiving Water Limitation 1, change the concentrations for Iron to read:

Parameter	Unit	Concentrations 1-Hour Average[1]	Concentrations 4-Day Average
Cadmium[2]	µg/l	2.0	1.3
Copper[2]	µg/l	7.0	5.0
Iron	µg/l	1,000	---
Lead[2]	µg/l	30	1.2
Mercury	µg/l	2.1	0.012
Zinc[2]	µg/l	65	66

[1] The discharge(s) shall not exceed the 1-hour average more than once every 3 years.
[2] Receiving water limitations for cadmium, copper, lead, and zinc vary with hardness of the receiving waters. The above limitations are calculated using a hardness of 50 mg/l as $CaCO_3$ using the following equations (from USEPA National Recommended Water Quality Criteria, 10 December 1998):

1-Hour Average

$$\text{Cadmium} = e^{1.128(\ln(\text{hardness}))-3.6867} \times (1.136672-\ln(\text{hardness}) \times 0.041838)$$
$$\text{Copper} = e^{0.9422(\ln(\text{hardness}))-1.7} \times 0.96$$
$$\text{Lead} = e^{1.273(\ln(\text{hardness}))-1.46} \times (1.46203-\ln(\text{hardness}) \times 0.145712)$$
$$\text{Zinc} = e^{0.8473(\ln(\text{hardness}))+0.884} \times 0.978$$

4-Day Average

$$\text{Cadmium} = e^{0.7852(\ln(\text{hardness}))-2.715} \times (1.101672-\ln(\text{hardness}) \times 0.041838)$$
$$\text{Copper} = e^{0.8545(\ln(\text{hardness}))-1.702} \times 0.96$$
$$\text{Lead} = e^{1.273(\ln(\text{hardness}))-4.705} \times (1.46203-\ln(\text{hardness}) \times 0.145712)$$
$$\text{Zinc} = e^{0.8473(\ln(\text{hardness}))+0.884} \times 0.986$$

The hardness for compliance purposes shall be based on sampling of Dolly Creek upstream of the Walker Mine's influence at the intersection of Road 24N11 and Road 24N09 (background station R-1).

2. Oils, greases, waxes, or other materials to form a visible film or coating on the water surface or on the stream bottom.

3. Oils, greases, waxes, floating material (liquids, solids, foams, and scums), or suspended material to create a nuisance or adversely affect beneficial uses.

4. Aesthetically undesirable discoloration.

5. Fungi, slimes, or other objectionable growths.

6. Turbidity to increase more than 20 percent over background levels.

7. The normal ambient pH to fall below 6.5, exceed 8.5, or change by more than 0.5 units.

8. Deposition of material that causes nuisance or adversely affects beneficial uses.

9. The normal ambient temperature to be increased more than 5?F.

10. Taste or odor-producing substances to impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or to cause nuisance or adversely affect beneficial uses.

11. Aquatic communities and populations, including vertebrate, invertebrate, and plant species, to be degraded.

12. Toxic pollutants to be present in the water column, sediments, or biota in concentrations that adversely affect beneficial uses; that produce detrimental response in human, plant, animal, or aquatic life; or that bioaccumulate in aquatic resources at levels which are harmful to human health.

13. Violations of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board (SWRCB) pursuant to the CWA and regulations adopted thereunder.

E. Provisions

1. Submit a complete Report of Waste Discharge, including the $10,000 filing fee, by **16 August 1999**.

2. The Discharger shall conduct the chronic toxicity testing specified in the Monitoring and Reporting Program. If the testing indicates that the discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above the water quality objective for toxicity, the Discharger shall submit a workplan to conduct a Toxicity Reduction Evaluation (TRE) and upon approval conduct the TRE, and this Order will be reopened and a toxicity limitation included and/or a limitation for the specific toxicant identified in the TRE included. Additionally, if a chronic toxicity water quality objective is adopted by the SWRCB, this Order may be reopened and a limitation based on that objective included.

3. The Discharger shall comply with all the items of the "Standard Provisions and Reporting Requirements for Waste Discharge Requirements (NPDES)," dated 1 March 1991, which are part of this Order. This attachment and its individual paragraphs are referred to as "Standard Provision(s)."

4. The Discharger shall comply with attached Monitoring and Reporting Program No. 99-110, which is part of this Order, and any revisions thereto, as ordered by the Executive Officer.

   When requested by USEPA, the Discharger shall complete and submit Discharge Monitoring Reports. The submittal date shall be no later than the submittal date specified in the Monitoring and Reporting Program for Discharger Self-Monitoring Reports.

5. This Order expires on **28 July 2004**, and the Discharger must file a Report of Waste Discharge in accordance with Title 23, CCR, not later than **180 days** in advance of such date in application for renewal of waste discharge requirements if it wishes to continue the discharge.

6. In the event of any change in control or ownership of land or waste discharge facilities described herein, the Discharger shall notify the succeeding owner or operator of the existence of this Order by letter, a copy of which shall be immediately forwarded to this office.

To assume operation under this Order, the succeeding owner or operator must apply in writing to the Executive Officer requesting transfer of the Order. The request must contain the requesting entity's full legal name; the state of incorporation, if a corporation; the name, address, and telephone number of the persons responsible for contact with the Board; and a statement. The statement shall comply with the signatory paragraph of Standard Provision D.6, and state that the new owner or operator assumes full responsibility for compliance with this Order. Failure to submit the request shall be considered a discharge without requirements, a violation of the California Water Code. Transfer shall be approved or disapproved in writing by the Executive Officer.

I, GARY M. CARLTON, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region, on 28 July 1999.

GARY M. CARLTON, Executive Officer

Attachments

AMENDED

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO. 99-111

REQUIRING
CEDAR POINT PROPERTIES, INC.
WALKER MINE
PLUMAS COUNTY
TO CEASE AND DESIST FROM
VIOLATING WASTE DISCHARGE REQUIREMENTS

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Board) finds that:

1. On 28 July 1999, the Board adopted Order No. 99-110 which established an NPDES permit for discharges of acid mine drainage (AMD) from the Walker Mine owned by Cedar Point Properties, Inc., (hereafter Discharger).

2. Waste Discharge Requirements Order No. 99-110 provides, in part, the following:

"A. Discharge Prohibitions

1. By-pass or overflow of untreated or partially treated acid mine drainage (AMD) is prohibited."

"B. Effluent Limits (Discharge 001, 002, and 003)

1. The discharge of treated AMD in excess of the following limits is prohibited:

Parameter	Unit	30-Day Average	Daily Maximum
Copper	µg/l	150	300
Zinc	µg/l	750	1500
Cadmium	µg/l	50	100
Mercury	µg/l	1	2
Lead	µg/l	300	600
Total Suspended Solids	mg/l	20	30

1. Survival of test fishes in 96-hour bioassays of undiluted waste shall be no less than:

Minimum for any one bioassay ----------70%
Median for any three or more bioassays ---------90%"

"C. Discharge Specifications

1. Neither the treatment nor the discharge shall cause a pollution or nuisance as defined by the California Water Code, Section 13050."

"D. Receiving Water Limitations

Receiving Water Limitations are based upon water quality objectives contained in the Basin Plan. As such, they are a required part of this permit.

The discharge shall not cause the following in Dolly Creek:

1. Concentrations of heavy metals to exceed the following:

Parameter	Unit	Concentrations 1-Hour Average[1]	Concentrations 4-Day Average
Cadmium[2]	µg/l	2.0	1.3
Copper[2]	µg/l	7.0	5.0
Iron	µg/l	1000	---
Lead[2]	µg/l	30	1.2
Mercury	µg/l	2.1	0.012
Zinc[2]	µg/l	65	66

[1] The discharge(s) shall not exceed the 1-hour average more than once every 3 years.

[2] Receiving Water Limitations for cadmium, copper, lead, and zinc vary with hardness of the receiving waters. The above limitations are calculated using a hardness of 50 mg/l as $CaCO_3$ using the following equations (from USEPA National Recommended Water Quality Criteria, 10 December 1998):

1-Hour Average

Cadmium = $e^{1.128(\ln(\text{hardness}))-3.6867} \times (1.136672-\ln(\text{hardness}) \times 0.041838)$
Copper = $e^{0.9422(\ln(\text{hardness}))-1.7} \times 0.96$
Lead = $e^{1.273(\ln(\text{hardness}))-1.46} \times (1.46203-\ln(\text{hardness}) \times 0.145712)$
Zinc = $e^{0.8473(\ln(\text{hardness}))+0.884} \times 0.978$

4-Day Average

Cadmium = $e^{0.7852(\ln(\text{hardness}))-2.715} \times (1.101672-\ln(\text{hardness}) \times 0.041838)$
Copper = $e^{0.8545(\ln(\text{hardness}))-1.702} \times 0.96$
Lead = $e^{1.273(\ln(\text{hardness}))-4.705} \times (1.46203-\ln(\text{hardness}) \times 0.145712)$
Zinc = $e^{0.8473(\ln(\text{hardness}))+0.884} \times 0.986$

The hardness for compliance purposes shall be based on sampling of Dolly Creek upstream of the Walker Mine's influence at the intersection of Road 24N11 and Road 24N09 (background Station R-1)."

3. The Discharger is violating and threatening to continue to violate the requirements in Finding No. 2 above in that untreated AMD containing constituents in excess of the limits specified in Finding No. 2 continues to be discharged to Dolly Creek which is tributary to Little Grizzly Creek, Indian Creek, and East Branch, North Fork Feather River.

4. The discharge of AMD has caused the concentrations of heavy metals in the receiving waters, including copper and zinc, to exceed the limits established in the Basin Plan for protection of aquatic life. Compliance with the requirements in Finding No. 2 will reduce or eliminate the possibility of impacts of heavy metals on aquatic life in Dolly Creek, Little Grizzly Creek, Indian Creek, and East Branch, North Fork Feather River.

5. Releases from the portal, sediment pond, and waste rock piles continue to discharge AMD into surface waters in violation of Discharge Prohibitions, Effluent Limitations, Discharge Specifications, and Receiving Water Limitations contained in the NPDES permit.

6. The Discharger, in order to comply with requirements set forth in Order No. 99-110, must implement control measures to reduce AMD from the property.

7. Cleanup and Abatement Order No. 97-715, issued by the Executive Officer on 7 October 1997, requires the Discharger to conduct remedial activities at the site to mitigate the release of pollutants into nearby creeks. The Discharger has not complied with any of the conditions or tasks specified in Order No. 97-715.

8. The beneficial uses of the North Fork Feather River are municipal and domestic supply, power generation, recreation, preservation and enhancement of cold-water fisheries and spawning habitat (aquatic life), and wildlife.

9. The Basin Plan states that the beneficial uses of any specifically identified water body generally apply to its tributary streams. Existing and potential beneficial uses of Dolly Creek and Little Grizzly Creek, tributaries to North Fork, Feather River, include recreation, preservation and enhancement of cold water fisheries and spawning habitat (aquatic life), and wildlife. Historically, prior to impacts to the watercourses from mining, Dolly Creek and Little Grizzly Creek were considered a prime cold-water fishery. The watercourses are currently utilized for recreation and preservation and enhancement of wildlife. The Basin Plan also lists Dolly Creek and Little Grizzly Creek as Water Quality Limited Segments for aquatic life downstream of the Walker Mine.

10. Issuance of this Order is exempt from the provisions of the California Environmental Quality Act (Public Resources Code Section 21000, et seq.), in accordance with Section 15321(a)(2), Title 14, California Code of Regulations.

11. Any person adversely affected by the action of the Board may petition the State Water Resources Control Board to review the action. The petition must be received by the State Board within **30 days** of the date the Board took action. Copies of the law and regulations applicable to filing petitions will be provided on request.

12. On 28 July 1999, in Sacramento, California, after due notice to the Discharger and other affected persons, the Board conducted a public hearing at which the Discharger appeared and evidence was received concerning the discharge.

IT IS HEREBY ORDERED that Cedar Point Properties, Inc., comply with the following:

1. Cedar Point Properties Inc., shall cease and desist discharging wastes in violation or threatened violation of Waste Discharge Requirements Order No. 99-110 as described in Finding No. 2, and implement corrective actions in accordance with the tasks and time schedules specified below:

Task	Compliance Date
a. Hire, and retain through the duration of this Order, a consultant experienced in water quality issues at abandoned mines, NPDES permits, erosion control, water quality sampling, and analysis. The responsible consultant shall either be a registered professional engineer or a certified engineering geologist.	**2 August 1999**
b. Begin evaluation of the quality and quantity of the discharges from the portal, sediment pond, and waste rock piles.	**2 August 1999**
c. Submit a workplan and time schedule describing how the Discharger proposes to operate and maintain the existing remedial structures. The report shall address each item described in staff's June 1997 *Operations and Maintenance Procedures*.	**1 December 1999**
e. Submit workplan and time schedule proposing effective methods for controlling pollutants in the discharges such that compliance is met with the effluent limits and receiving water limits specified in Order No. 99-110.	**1 August 2000**
f. Complete implementation of all corrective actions necessary for discharges from the portal, sediment pond, and waste rock piles, and achieve full compliance with Order No. 99-110.	**1 October 2002**

2. The Discharger shall conduct the work only after workplans are approved or conditionally approved by Regional Board staff. The Discharger must incorporate all conditions of approval into the workplan. The Discharger may not make any modifications to any workplan without a written request to staff and a written approval by staff. Unless the Discharger received written approval for modification of a workplan, failure to complete every item in an approved workplan will be considered a violation of this Order.

IT IS FURTHER ORDERED that, pursuant to Section 13223 of the California Water Code, if the Discharger fails to comply with the provisions of this Cease and Desist Order, the Regional Board authorizes the Executive Officer to apply to the Attorney General for judicial enforcement or issue a complaint for Administrative Civil Liability.

I, GARY M. CARLTON, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region, on 28 July 1999.

GARY M. CARLTON, Executive Officer

AMENDED 7/28/99 PVW:djc/icc

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

Twining Eddie (owner) 559-978-9571
wed am

7 December 1999

	Method
TDS - 1 bottle	2540C
pH	150.1
Sulfate } 1 bottle	300.
Copper	200.7 ICP

DISCHARGER: Walker Mine

LOCATION & COUNTY: Plumas

CONTACT (S):

INSPECTION DATES: 2,3, and 10 November 1999

INSPECTED BY: Patrick Morris

ACCOMPANIED BY:

SUBJECT: **WALKER MINE SEAL INSPECTION AND WATER QUALITY SUMMARY, NOVEMBER 1999**

Mine Seal Inspection:

Gordon Taylor (CalOSHA mine inspector) inspected the Walker Mine adit and mine seal on 19 October 1999. Mr. Gordon found the timber sets to be in good condition. The unsupported section had a few areas where the rock was loose and required minor scaling. Rock that came down was arranged in piles so that we would be able to monitor future spalling.

On 19 October the pressure gage indicated 77 psig (178 feet of pressure head). There was minor seepage (estimated to be 0.2 gpm) flowing from the mine seal roof and sides. The amount of seepage was unchanged since the last seal inspection (October 1998). We have considered installing a weir or other flow measurement device but it may be difficult to measure such low flows. The volume of water pooled in front of the seal was estimated to be 600 gallons.

A water sample collected from the seal seepage had the following chemistry: pH 4.1, TDS 320 mg/l, sulfate 180 mg/l, and dissolved copper 13,000 µg/l. 1 bottle

The Telog pressure data recorder was downloaded on 10 November 1999 and charged batteries were installed for the winter. The Telog indicated 7.76 mA (pressure head equivalent to 172 feet). The total battery voltage was 14.4 VDC (fresh batteries have over 24 VDC). This voltage is low for only five months of usage therefore new batteries should be installed next spring.

The portal door continues to be very difficult to close and should be repaired the next time a contractor is working in the portal area.

Approved:		

Water Quality:

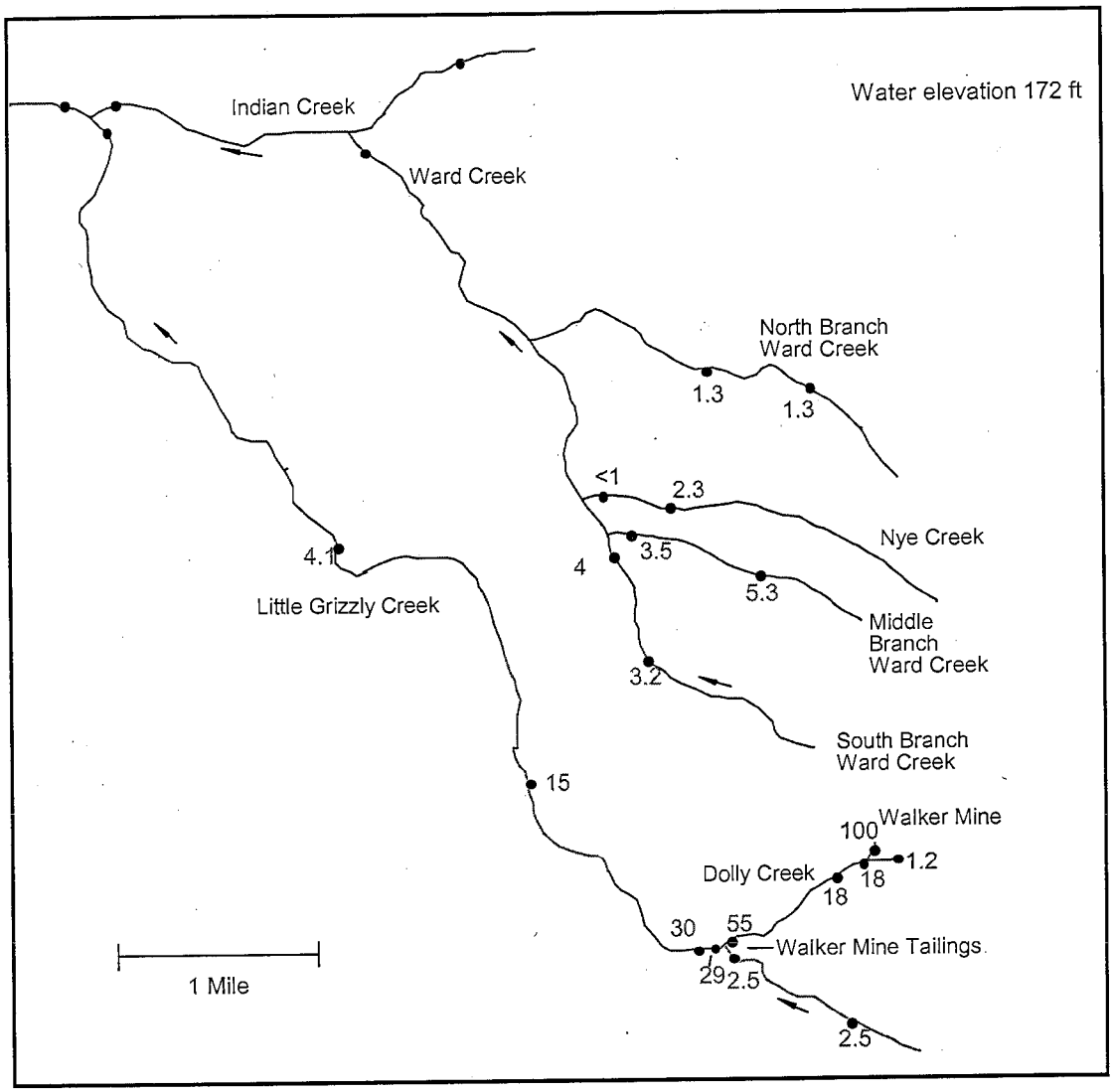
Surface water samples from Dolly, Little Grizzly, Nye, and Ward Creeks were collected on 2 November 1999. Table 1 summarizes the pH, EC, and dissolved copper concentrations, and Figure 1 shows the concentrations on a map. Complete analytical results are contained in the *Walker Mine Water Quality Database*.

Table 1
Surface Water Quality

Sample ID	*pH*	*EC (µmhos/cm)*	*Copper (dissolved, µg/l)*
1. **Portal**	7.8	110	100
2. **DC Upstream**	7.8	141	1.2
3. **DC Downstream**	8.0	138	18
4. **DC @48" culvert**	8.1	139	18
5. **LGC upstream**	8.0	119	2.5
6. **USFS dam**	8.1	143	55
7. **LGC above DC**	7.9	157	2.5
8. **LGC below DC**	7.7	150	29
9. **LGC @ Browns Cabin**	7.8	150	30
10. **LGC @25N05Y**	8.1	157	15
11. **S. Br. Ward Creek, 25N42**	8.2	47	3.2
12. **Mid. Br. Ward Creek, 25N42**	7.7	31	5.3
13. **Nye Creek, 25N42**	6.8	112	2.3
14. **So. Br. Ward Creek, 25N32Y**	7.3	174	4
15. **Mid. Br. Ward Creek, 25N32Y**	7.9	130	3.5
16. **Nye Creek, 25N32Y**	7.2	133	<1
17. **No. Br. Ward Creek, 25N42**	6.7	151	1.3
18. **No. Br. Ward Creek, 25N32Y**	7.6	147	1.3
19. **Settling Pond Discharge**	8.1	125	110

Figure 1
Dissolved Copper Concentrations (µg/l)

November 1999



Monitoring Well

On 3 November, Koll Buer (DWR) assisted in sampling the monitoring well. The water depth was 564.15 feet to top of casing (565.0 feet bgs). Due to logging operations and pump malfunctions, the water samples were not collected from the well's screened interval (at the stoped area, 720 feet bgs) but were collect from 652 feet bgs, 68 feet above the mine pool. The well was not purged. Water data indicate the pH ranged from 7.9 to 8.1 pH units and TDS ranged from 150 to 160 mg/l. Dissolved copper ranged form 4.6 to 16 µg/l. Based on these observations, it is evident that the water samples were groundwater that has not mixed with mine pool water. Next summer the pump will be lowered to the screened interval and the well purged before sample collection.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO. 5-00-028

WASTE DISCHARGE REQUIREMENTS
FOR
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE, PLUMAS NATIONAL FOREST
WALKER MINE TAILINGS
PLUMAS COUNTY

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Board) finds that:

1. The Walker Mine Tailings are on public land administered by the U.S. Department of Agriculture, Forest Service, Plumas National Forest (USFS, hereafter referred to as Discharger). The nearby Walker Mine generated the tailings from copper mining activities that occurred from 1916 to 1941.

2. The Walker Mine Tailings (tailings) are in east central Plumas County about 20 miles east of Quincy and 20 miles north of Portola in Section 12, T24N, R11E and Sections 7 and 18, T24N, R12E, MDB&M, as shown on Attachment A. The total area of the tailings is about 100 acres and averages 28 feet in depth. The tailings are at the confluence of Dolly Creek and Little Grizzly Creek, as shown on Attachment B.

3. Waste Discharge Requirements Order No. 91-017 previously regulated the tailings. Order No. 91-017 is being updated to reflect water quality improvements at the site and to provide a compliance time schedule for additional improvements. These revised requirements also modify the monitoring and reporting program.

4. In 1991, the U.S. Environmental Protection Agency placed the site on the Federal Agency Hazardous Waste Compliance Docket pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act. The USFS adopted a Federal Record of Decision for the tailings in June 1994. The remedial actions selected for the site include channel erosion control, development of wetlands for passive water treatment, revegetation, and wind erosion control.

5. The Walker Mine Tailings site is downstream from the Walker Mine. During the operation of the mine, tailings from the mill were deposited in a constructed basin at the confluence of Dolly and Little Grizzly Creeks. Dolly Creek crosses the tailings in a northeast- southwest direction. Dolly Creek exits the tailings at a structure referred to as the "USFS Dam" and is identified as "R-2" on Attachment B.

6. An undetermined amount of storm water runoff is collected in a settling pond, which is about 2,300 feet southeast of the USFS Dam along the southern edge of the tailings. The settling

pond is equipped with a drop inlet culvert that discharges directly to Little Grizzly Creek. The discharge from the drop inlet culvert is identified as "R-6" on Attachment B.

7. These WDRs regulate the discharges from R-2, R-6, and unidentified non-point source discharge(s) such as leakage through the levee that separates Little Grizzly Creek from the tailings area.

8. In November 1987, the Board installed a mine seal in the Walker Mine, upstream of the tailing site, to reduce the loading of heavy metals (copper, iron, and zinc) on Dolly Creek and Little Grizzly Creek. This mine seal has resulted in a significant reduction in heavy metals loading to these waters.

9. Water quality data indicate that the Walker Mine tailings continue to contribute significant concentrations of copper to Dolly Creek. The dissolved copper concentration upstream of the tailings averages 22 μg/l while copper concentrations at the USFS dam average 119 μg/l (data from 1996 through 1998).

10. To contain the Walker Mine tailings, a levee was constructed along the west bank of Little Grizzly Creek and the flashboard dam (USFS Dam) was installed across the mouth of Dolly Creek. The USFS Dam prevents a majority of the tailings from washing downstream. However, the tailings continue to erode and flow into surface waters during rainfall events and snowmelt periods. The tailings are a water quality threat because of the existing and potential for release of tailings and turbid water to Dolly Creek and Little Grizzly Creek.

11. In 1991, the USFS constructed four acres of wetlands and stabilized 1500 feet of Dolly Creek on the tailings. The USFS designed the wetlands to function anaerobically, but the wetlands went aerobic due to sedimentation problems during the stream stabilization program.

12. The USFS 1994 Record of Decision (ROD) proposed two approaches to reduce the discharge of pollutants from the site. The first approach of the ROD is to provide additional stabilization of the Dolly Creek channel to reduce erosion and sedimentation and to create additional wetlands systems to reduce metal discharges into Dolly Creek. The USFS had planned to build a total of 15 acres of wetlands; however, they have constructed and maintained four acres.

13. The ROD evaluated diversion of Dolly Creek around the tailings if channel stabilization and the wetlands did not improve water quality to meet receiving water limitations. The diversion of Dolly Creek around the tailings would reduce the amount water requiring treatment within the wetlands. Monitoring data indicate that the initial Dolly Creek work has been only moderately effective in reducing metal discharges. Therefore, these WDRs require the Discharger to divert Dolly Creek and expand the wetlands area or take other effective actions to improve water quality in Dolly Creek.

14. The second approach of the ROD is to reduce erosion and metals loading from the remainder of the tailings. The Discharger has installed wind fences on 50 acres to control wind-induced erosion and initiated revegetation. Revegetation is expected to reduce wind erosion and reduce the oxygen in the acid producing upper layer (vadose zone) of the tailings therefore reducing the release of metals to groundwater and surface water. These WDRs require the Discharger to conduct additional revegetation on the mine tailings area or take other effective action to reduce erosion.

15. These WDRs protect beneficial uses of Little Grizzly Creek listed in Finding 18 and will comply with water quality objectives and goals throughout the length of Little Grizzly Creek. The Board recognizes that water quality in Dolly Creek upstream of the mine tailings may not meet water quality criteria for freshwater aquatic life. The Board also recognizes that the USFS may not be able to meet the receiving water limitations set forth in these WDRs due to the discharges from the upstream Walker Mine. However, the Discharger must continue to mitigate releases from the tailing site to Dolly Creek and comply with the receiving water limits and the compliance schedule listed in these WDRs. Reductions in the metal loading from the tailings into Dolly Creek will allow Little Grizzly Creek to meet water quality criteria.

16. Surface drainage from the tailings is to Dolly Creek and Little Grizzly Creek, both perennial streams. Little Grizzly Creek is tributary to Indian Creek, which is tributary to the East Branch, North Fork Feather River, which is tributary to the Feather River, thence to the Sacramento River.

17. This Order implements the Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin, Fourth Edition, (hereafter Basin Plan) which designates beneficial uses, establishes water quality objectives, and describes an implementation program and policies to achieve those objectives for all waters of the Basin. These requirements implement the Basin Plan.

18. The beneficial uses of the North Fork, Feather River are municipal and domestic supply, power generation, recreation, preservation and enhancement of cold-water fisheries and spawning habitat (aquatic life), and wildlife. Existing and potential beneficial uses of Dolly Creek and Little Grizzly Creek include recreation, preservation and enhancement of cold water fisheries and spawning habitat (aquatic life), and wildlife. Historically, before impacts to the watercourses from mining, Dolly Creek and Little Grizzly Creek were considered a prime cold-water fishery. The watercourses are currently utilized for recreation, preservation, and enhancement of wildlife. The Basin Plan also lists Dolly Creek and Little Grizzly Creek as Water Quality Limited Segments for aquatic life.

19. The mine tailings form a perched aquifer with the groundwater elevation dependent on the elevation of the USFS Dam. Groundwater elevations beneath the mine tailings average 5.7 feet below the surface of the tailings, ranging from 0.4 feet to 17 feet. Groundwater flow direction is towards Little Grizzly Creek.

20. The groundwater monitoring network consists of seven monitoring wells (see Attachment B). Monitoring data show that the tailings have impacted groundwater with copper (ranging from less than 10 μg/l to 1700μg/l). The impact of leachate from the tailings will be addressed through the tailings rehabilitation program required under compliance time schedule outlined in Provision E.9.

21. The beneficial uses of groundwater are domestic and municipal supply, agricultural supply, and industrial supply.

22. The action to update WDRs for this facility is exempt from the provisions of the California Environmental Quality Act in accordance with Title 14, California Code of Regulations, Sections 15301, 15308, and 15330.

23. The Board has notified the Discharger and interested agencies and persons of its intention to revise the waste discharge requirements for this facility.

24. In a public hearing, the Board heard and considered all comments pertaining to this facility and discharge.

IT IS HEREBY ORDERED that Order No. 91-017 is rescinded and the U.S. Department of Agriculture, Forest Service, Plumas National Forest and their agents, assigns and successors, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, shall comply with the following:

A. Discharge Prohibitions

1. Discharges causing the degradation of any water supply are prohibited.

2. Discharges having a pH less than 6.5 or greater than 8.5 are prohibited.

B. Discharge Specifications

1. Neither the treatment nor the discharge shall cause a pollution or nuisance as defined by the California Water Code, Section 13050.

2. Storm water discharges to any surface or groundwater shall not adversely impact human health or the environment.

3. Storm water discharges shall not cause or contribute to a violation of any applicable water quality standards contained in the Basin Plan.

C. Receiving Water Limitations

1. The discharge(s) shall not cause concentrations in Little Grizzly Creek at R-5 (immediately above Road 25N42 and above the west side spring discharge) to exceed the following limits:

Constituent	Units	Limitation
Copper	μg/l	5.0
Iron	μg/l	1000
Zinc	μg/l	66

2. The Discharger shall comply with the above receiving water limitations in accordance with the time schedule in Provision E.9. These limitations have been specified to protect the beneficial uses of surface water.

3. The discharge shall not cause visible oil, grease, scum, foam, and floating or suspended material in the receiving waters or watercourses.

4. The discharge shall not cause concentrations of any materials in the receiving waters that are deleterious to human, animal, aquatic, or plant life.

5. The discharge shall not cause aesthetically undesirable discoloration of the receiving waters.

6. The discharge shall not cause bottom deposits in the receiving waters.

7. The discharge shall not cause fungus, slimes, or other objectionable growths in the receiving waters.

8. The discharge shall not cause the turbidity of the receiving waters to increase as follows:

   a. More than 1 Nephelometric Turbidity Units (NTUs), where natural turbidity is between 0 and 5 NTUs.

   b. More than 20 percent, where natural turbidity is between 5 and 50 NTUs.

   c. More than 10 NTUs, where natural turbidity is between 50 and 100 NTUs.

   d. More than 10 percent, where natural turbidity is greater than 100 NTUs.

9. The discharge shall not alter the normal ambient pH of the receiving water more than 0.5 units.

10. The discharge shall not cause taste or odor producing substances to impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or to cause nuisance or adversely affect beneficial uses.

11. The discharge shall not cause aquatic communities and populations, including vertebrate, invertebrate, and plant species, to be degraded.

12. The discharge shall not cause toxic pollutants to be present in the water column, sediments, or biota in concentrations that adversely affect beneficial uses; that produce detrimental response in human, plant, animal, or aquatic life; or that bioaccumulate in aquatic resources at levels which are harmful to human health.

13. The discharge shall not cause violations of any applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board (SWRCB).

D. Financial Assurance

The U.S. Department of Agriculture shall provide and maintain a Federal Certification in accordance with Title 27 California Code of Regulations Section 22250.

E. Provisions

1. The Discharger shall comply with the Standard Provisions and Reporting Requirements, dated 1 March 1991, and which are hereby incorporated into this Order. A violation of any of the Standard Provisions and Reporting Requirements is a violation of these waste discharge requirements.

2. The Discharger shall comply with the reporting requirements specified in this Order, and with the monitoring and reporting requirements of Monitoring and Reporting Program Order No. 5-00-028, which is attached hereto and made part of this Order.

3. The Discharger shall implement an approved in-stream biotoxicity assessment program to determine in-stream toxicity resulting from site discharges and their effect on aquatic life in Little Grizzly Creek in accordance with the compliance time schedule outlined in Provision E.9.

4. The Discharger shall notify the Board within 24 hours of identifying any by-pass, overflow, or process failure of the drainage control(s) or treatment system(s).

5. The Discharger shall report promptly to the Board any material change or proposed change in character, location, or volume of the waste discharge.

6. By **15 December** of each year, the Discharger shall submit a progress report that describes that year's remedial activities and progress towards compliance with the Receiving Water Limitations listed in this Order.

7. By **1 October 2000** and every five years thereafter, the Discharger shall submit to the Board the results of the five-year review required by Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act.

8. The Discharger shall comply with applicable sections of the Clean Water Act (Sections 401 and 404), the California Environmental Quality Act, and all other applicable federal and state requirements before construction activities.

9. The Discharger shall comply with the following compliance time schedule:

Tasks	Compliance Date
A. In-stream Biotoxicity Assessment Program	
1. Submit a proposed in-stream biotoxicity assessment program.	**1 May 2001**
2. Implement in-stream biotoxicity assessment program.	**30 days after approval**
3. Submit results of the in-stream biotoxicity assessment program.	**Annually**
B. Dolly Creek Rehabilitation	
1. Submit workplan for diversion of Dolly Creek and improvement of wetlands or take other effective actions to improve water quality.	**1 November 2001**
2. Implement Dolly Creek and wetlands workplan.	**6 months after approval**
3. Complete workplan implementation.	**1 October 2004**

Tasks (continued)	Compliance Date
C. Tailings Rehabilitation Program	
1. Submit workplan for maintenance of wind erosion control and additional revegetation of mine tailings or take other effective action to enhance tailings rehabilitation program.	**1 November 2001**
2. Implement erosion and revegetation workplans.	**6 months after approval**
3. Complete workplan implementation.	**1 October 2005**
D. Receiving Water Limitations	
Full compliance with Receiving Water Limitations.	**1 October 2008**

9. In the event of any change in control or ownership of land or waste discharge facilities presently owned or controlled by the Discharger, the Discharger shall notify the succeeding owner or operator of the existence of this Order by letter, a copy of which shall be forwarded to this office.

10. The Board will review this Order periodically and may revise requirements when necessary.

I, GARY M. CARLTON, Executive Officer, do hereby certify the foregoing is a full, true and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region, on 28 January 2000.

GARY M. CARLTON, Executive Officer

Attachments

PWM

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

29 August 2000

DISCHARGER: Cedar Point Properties, Walker Mine

LOCATION & COUNTY: Plumas

CONTACT (S):

INSPECTION DATES: 20 and 21 June 2000

INSPECTED BY: Patrick Morris PWM

ACCOMPANIED BY:

SUBJECT: **WALKER MINE INSPECTION AND WATER QUALITY SUMMARY, JUNE 2000**

Walker Mine Inspection

On 20 June 2000 the Telog pressure data recorder indicated 72 psig (166 feet of pressure head). The recorder was downloaded and charged batteries were installed (new batteries purchased 15 June) for the summer monitoring period.

The total battery voltage of the set removed was 15.2 VDC (fresh batteries are 24 VDC). This voltage is low and it appears that at least two of the four batteries are bad. I will purchase and install a new set before winter. It appears that given the charge/discharge cycles that these batteries are subject to, the lead acid batteries should be replaced every 2-2.5 years.

The portal door continues to be very difficult to open and close and should be repaired when our contractor installs the secondary portal security door.

The heavy-duty chain and lock to the main gate were missing. A new set was purchased and installed.

There was no active timber harvest in progress at the time of the inspection. There was logging equipment near the sinkholes but no evidence that it had been used recently.

Water Quality:

Surface water samples from Dolly, Little Grizzly, Nye, and Ward Creeks were collected on 20 June 2000. Table 1 summarizes the pH, EC, and dissolved copper concentrations, and Figure 1 shows the concentrations on a map. Complete analytical results are contained in the *Walker Mine Water Quality Database*.

Flow from the Portal ranged from 5-10 gpm. Flow from the settling pond was less than one gpm.

Approved:	

Figure 1
Dissolved Copper Concentrations (µg/l)
June 2000

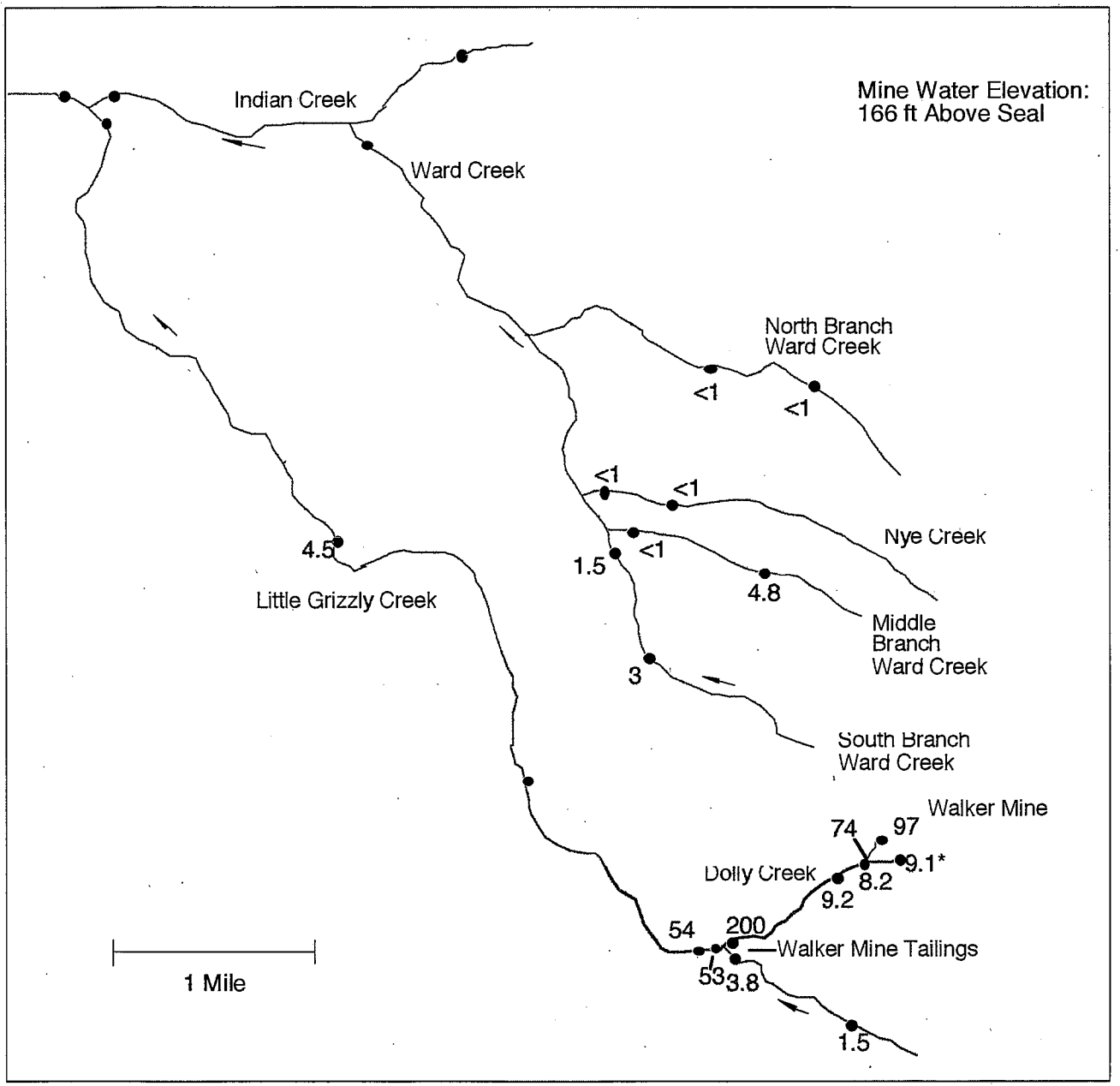


Table 1
Surface Water Quality

Sample ID	*pH*	*EC (µmhos/cm)*	*Copper (dissolved, µg/l)*
1. Portal	7.3	120	97
2. DC Upstream	8.0	140	9.1*
3. DC Downstream	8.0	120	8.2
4. DC @48" culvert	8.1	120	9.2
5. LGC upstream	7.9	84	1.5
6. USFS dam	8.1	120	200
7. LGC above DC	8.0	85	3.8
8. LGC below DC	8.0	95	53
9. LGC @ Browns Cabin	8.1	94	54
10. LGC @25N05Y	8.1	98	4.5
11. S. Br. Ward Creek, 25N42	7.8	41	3
12. Mid. Br. Ward Creek, 25N42	6.7	41	4.8
13. Nye Creek, 25N42	7.7	96	<1
14. So. Br. Ward Creek, 25N32Y	8	150	1.5
15. Mid. Br. Ward Creek, 25N32Y	8.1	110	<1
16. Nye Creek, 25N32Y	8.1	140	<1
17. No. Br. Ward Creek, 25N42	8.2	140	<1
18. No. Br. Ward Creek, 25N32Y	8.2	150	<1
19. Settling Pond Discharge	7.8	220	74

* Possible laboratory error- Total Copper < 1µg/l.
Note: Temperature corrected EC using YSI Model 63 EC/pH meter

Prebid Meeting

On 21 June 2000 I met with a representative from DGS for a mandatory prebid meeting for construction of the surface water diversion structures. About 10 contractors attended the meeting. We visited both the Piute and Central subsidence areas. We discussed site access, site conditions, using onsite materials for construction (riprap) and construction traffic conflicts with equipment for the ongoing timber harvest. Then we entered the portal to view the location of the secondary security gate. The gate will be installed at the end of the concrete section (before the beginning of the CMP). The ventilation fan will be relocated behind the new gate, about 20 feet back from its present location.

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

INSPECTION REPORT

28 November 2000

DISCHARGER: Cedar Point Properties, Walker Mine

LOCATION & COUNTY: Plumas

CONTACT (S):

INSPECTION DATES: 31 October – 2 November 2000

INSPECTED BY: Patrick Morris

ACCOMPANIED BY: GEI Consultants and subcontractors

SUBJECT: **WALKER MINE INSPECTION, NOVEMBER 2000**

Walker Mine Inspection

On 31 October 2000, I arrived at Walker Mine accompanied by GEI Consultants Inc. (Alberto Pujol) for the Mine Seal Integrity Testing Project. Simonis Logging Company was conducting logging operations along the road leading to the portal area. The weather was clear and cool (about 35°F). Several inches of snow were on the ground, with deeper sections in shaded areas. Temperatures during the day were high enough to melt the snow and that, in addition to the logging operations, made many sections of the road near the mine very muddy and difficult to pass. Four-wheel drive vehicles were a necessity.

Downed timber blocked the road to the portal. Simonis' equipment operators quickly moved the timber so that our vehicles could pass. Logging activities have damaged the main gate to the mine. The chain was cut but the lock was intact (this lock and chain had been installed in June 2000 with a key provided to Cedar Point Properties). The loggers have cut the large pine tree adjacent to the gate. Since it is unlikely that the loggers will repair the entry gate, we will have to repair or replace the gate and install a metal post in place of the pine tree.

The loggers' trailers were on the flat near the portal; however, there were no problems with access to the mine door. The boards that are between the rails that lead under the mine door had been moved in an attempt by unauthorized persons to enter the mine. The angle-iron grate (installed several years earlier) under the door was successful in preventing mine entry. A log truck driver informed me that he had witnessed someone inside the mine door after they had unlocked it. I was unaware anyone had keys to the mine and I saw no indications that the mine door had been open prior to my arrival. As a preventative measure, I purchased and installed new heavy-duty padlocks on the mine door after the inspection.

On 1 November 2000 the Telog pressure data recorder indicated 61 psig (141 feet of pressure head). The total battery voltage was 24.4 VDC, indicating that batteries were in ok condition. The recorder was downloaded and new batteries were installed (batteries purchased October 2000) for the winter monitoring period. The new battery set had 25.4 VDC.

Approved:		

GEI initiated seal testing activities. The subcontractors that participated with the site visit included Construction Technology Laboratories, Walker and Associates, Gary Mass, and the Washington Group International. GEI will be preparing and submitting a site visit report summarizing the observations. The following is a partial list of activities that GEI conducted:

Tailgate safety meeting and site familiarization
Pumping water in front of the seal to monitor seepage rates
Visual inspections of mine valves and concrete seal
Non-destructive testing of seal with Impulse Response and Impact Echo techniques
Collection of water samples from pooled area, water in pipe and water behind seal
Meeting to discuss results of preliminary investigation

Water Samples:

I collected surface water samples from Dolly Creek and the portal on 31 October 2000. Table 1 summarizes the pH, EC, and dissolved copper concentrations.

The portal flow was about 10 gpm. Flow from the settling pond was about one gpm. I collected a sample from the settling pond discharge pipe but the water level was too low to accurately measure the field pH and EC with the meter. Flow at Dolly Creek Downstream was greater than 300 gpm.

Table 1
Water Quality

Sample ID	*pH*	*EC (µmhos/cm)*	*Copper (dissolved, µg/l)*
1. Portal	7.5	97	74
2. DC Upstream	7.9	140	1.5
3. DC Downstream	7.7	139	32
19. Settling Pond Discharge	7.5 (lab)	270 (lab)	100

Note: Temperature corrected EC using YSI Model 63 EC/pH meter