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OREGON
ENVIRONMENTAL QUALITY
COMMISSION MEETING
MATERIALS 02/07/1992

DEQ

State of Oregon
Department of Environmental Quality

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State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

REQUEST FOR PROPOSALS
FOR
TECHNICAL ADVICE ON MINING RULES

February 7, 1992

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ATTACHMENTS

I. GENERAL INFORMATION

A. Introduction

The Environmental Quality Commission (Commission) is considering adoption of rules to require mining operations using cyanide or other toxic chemicals to protect soils, groundwater, surface waters, and wildlife from contamination or harm by process solutions and waste waters. The protective measures required by the proposed rules include cyanide recovery and re-use, chemical detoxification of cyanide residues, and extensive lining and engineered closure of waste disposal facilities.

During the public participation process on the proposed rules, mining companies and associations have argued that some of the requirements are unnecessarily stringent or are unproven or are unavailable. Environmental protection organizations have argued that the proposed rules may not be adequately protective in certain respects.

The Commission has studied the proposed rules and the public comments received, and has extensively debated the policy issues associated with the rule proposal. Prior to final action to adopt proposed rules, the Commission has elected to seek an evaluation and advice on specific technical questions from an independent, knowledgeable contractor.

The entire record of the rulemaking proceeding is available for inspection as background material for this proposal request. The record can be reviewed in the headquarters office of the Department of Environmental Quality (DEQ or Department or Agency). A full copy of the draft proposed rules being considered by the Environmental Quality Commission is attached as Attachment B.

B. Proposed Project Timeline

Date	Action
February 7, 1992	Mail Request for Proposal
February 28, 1992	Information Exchange (to take place only between mailing of the RFP and this date)
March 10, 1992	Written Proposals Due
March 20, 1992	Selection of Contractor (written notice of award to successful proposer)

March 30, 1992	Protest Period (protests must be filed by this date)
April 10, 1992	Execution of Standard State Personal Service Contract (target date)
Within 15 calendar days of Contract Execution:	Participate in Public Meeting.
Within 45 calendar days of Contract Execution:	Draft Written Report submitted to DEQ.
Within 15 calendar days of Receipt of Comments from DEQ:	Submit Final Report.

C. Services Requested

DEQ is requesting proposals from individuals acting as independent contractors (see attached Independent Contractor Certification Statement form), firms, joint ventures or teams for providing advice to the Commission on technical issues related to proposed rules for mining operations using chemicals to extract metals from ores. Companies interested in pooling their resources through contractor/subcontractor, joint ventures or team arrangements can do so provided that one entity is identified which ultimately will bear total contract responsibility.

D. Scope of Work

Three policies have been established by the Commission. The selected contractor shall evaluate and address specific technical questions surrounding these policies. The Commission is not asking for alternative policy recommendations or evaluation of economic issues. The task of the contractor is to answer the questions posed in the following paragraphs based on their knowledge, expertise, experience, review of current published technical data, and technical evaluation of the issues.

1. Questions on Liners, Leak Detection, and Leak Collection Systems

a. Statement of Policy:

The Commission establishes as policy that a liner, leak detection and leak collection system are necessary to assure that any leak will be detected before toxic materials escape from the liner system and are released to the environment. These systems must assure that if a leak is found, sufficient time is available to allow for the repair of the leak and clean up of any leaked material before there is a release to the environment. Natural conditions, such as depth to groundwater or net rainfall, shall be considered as additional protection but not in lieu of the protection required by the required engineered protection.

NOTE: Definition of "environment" or use of defining qualifiers is central to the issue. The Commission considers that the environment begins at the bottom of the last liner.

b. Issue:

In the proposed rule contained in 340-43-065(4), the requirements for heap leach pad liners are as follows:

(4) The heap leach pad liner system shall be of triple liner construction with between liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible membrane middle and top liners of suitable synthetic material separated by a minimum of 12 inches of permeable material (minimum permeability of 10^{-2} cm/sec);

(c) A leak detection system between the synthetic liners capable of detecting leakage of 400 gallons/day acre within ten weeks of leak initiation.

As opposed to this liner system, the Oregon Mining Council has proposed a liner characterized either as a composite liner or as a double liner and generally described as follows:

Composite Liner -- a composite liner system construction with between liner leak detection consisting of:

- An engineered, stable, low-permeability soil/clay bottom liner (maximum coefficient of permeaability of 10^{-7} cm/sec) with a minimum thickness of 12 inches;

- Continuous flexible membrane top liner of suitable synthetic material;

- A geotextile layer between the liner materials for leak detection. The leak detection and recovery system would also include collector pipes tied to the geotextile, spaced at appropriate intervals to achieve the 10-week leak initiation detection performance standard.

c. Question:

Will either or both liner systems meet the stated policy objective of the Commission?

d. Method to Answer or Address Question:

(1) Are each of the various liner systems proposed technically feasible?

(2) Will each of the various liner systems meet the stated Commission policy?

(3) For those liner systems which will meet the stated Commission policy, what level of certainty for achieving this policy do you assign to each system?

(4) Are there other liner systems which will achieve this policy and what level of certainty for achieving this policy do you assign to each?

The consultant is also asked to provide a simple comparison of typical costs for installation of the various liner configurations.

2. Questions on Tailings Treatment to Reduce the Potential for Release of Toxics

a. Statement of Policy:

The Commission establishes as policy that the toxicity and potential for long-term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment.

b. Issue:

The proposed rules in 340-43-070(1) state the following:

(1) Mill tailings shall be treated by cyanide removal and re-use prior to disposal to reduce the amount of cyanide introduced into the tailings pond. Chemical oxidation or other means shall be additionally used, if necessary, prior to disposal to reduce the WAD cyanide level in the

liquid fraction of the tailings. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak-acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm.

The rules do not require removal of potentially toxic metals from tailings prior to placement in the tailings pond. The rules do require steps to control acid formation in the tailings pond and require covering upon closure with a composite cover designed to prevent water and air infiltration.

c. Question:

Do the requirements for **removal** and **reuse** of cyanide materially reduce toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

d. Method to Answer or Address Question:

(1) Are **removal** and **reuse** technically feasible?

Potential factors for consideration include:

- Is the process technically defined and understood?
- Has the process been demonstrated in practical application, and if so, where?
- Are engineering firms available to design and oversee construction?
- Are materials and equipment available to construct?

(2) Do **removal** and **reuse** (evaluated separately) materially reduce the toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

(3) What is the level of certainty you give to the answers provided above?

(4) Are there other tailings treatment technologies which will equally, or more effectively achieve the policy of the Commission?

3. Questions on Closure of the Heap Leach and Tailings Facilities

a. Statement of Policy:

The Commission establishes as policy that the closure of the heap leach and tailings disposal facilities will prevent release to the environment of toxic chemicals contained in the facility.

b. Issue:

Rule 340-43-080(4)(a), as proposed, requires that the heap shall be "... detoxified over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The WAD cyanide concentration in the rinsate shall be no greater than 0.2 ppm."

In 340-43-080(4)(b), the proposed rules require that the closure of the heap shall be "... by covering the heap with a cover designed to prevent water and air infiltration."

In 340-43-080(5), the proposed rules state that "The tailings disposal facility shall be closed by covering with a composite cover designed to prevent water and air infiltration and be environmentally stable for an indefinite period of time."

c. Question:

Do the requirements of detoxification (cyanide removal by rinsing) of the heap and covering of the heap and tailings facility to exclude air and water materially reduce the likelihood of any release to the environment of toxic chemicals and metals contained in the heap over the long term?

d. Method to Answer or Address Question:

(1) Are detoxification and covering (as prescribed in this rule) technically feasible?

(2) Do detoxification and covering (evaluated separately and together) materially reduce the likelihood of a release of toxic chemicals and metals to the environment?

(3) What is the level of certainty you give to the answers provided above?

(4) Are there other technologies which can equally or more effectively achieve the policy of the Commission?

4. Public Meeting

In addition to answering the above questions, the selected contractor will be expected to participate in a meeting with persons who have expressed an interest in the rulemaking proceeding by presenting testimony at public hearings. The purpose of this meeting will be to:

- Inform the interested public on the contractors approach and schedule for addressing the questions posed.

- Identifying any anticipated need to contact persons who presented testimony in the proceeding for additional information to assist in addressing the questions posed. The Commission expects an open process where all interested parties will have the opportunity to attend the meeting.

This meeting will be scheduled at a time and place mutually agreeable to DEQ and the selected contractor. DEQ will arrange the meeting and provide notice to interested parties.

5. Written Report

A written report shall be submitted as the final product of this contract. The report shall state the question being answered, summarize the methodologies for evaluating and responding to the question, and clearly state the results of the evaluation and answer given.

A draft report shall be submitted to the Department for review. The Department will provide written comments to the contractor. The contractor will then complete the report and file a single master copy, ready for reproduction, with the Department. The report shall become the property of the Department. The Department may copy and distribute the report as it deems appropriate.

E. Type of Contract

DEQ anticipates awarding a fixed price contract. The State of Oregon standard personal service contract will be signed.

DEQ will, in its sole discretion, reserve the right to renew the contract.

F. Payment Procedure

Payment schedules for any contract entered into as a result of the RFP will be mutually agreed upon by DEQ and the prime contractor.

G. <u>Managing Conflict of Interest</u>

Proposing contractors (including subcontractors) shall disclose any potential conflicts of interest. A potential conflict of interest includes, but is not limited to, any involvement during the past five years with mining companies, mining industry groups, or environmental groups active in working on mining regulations and permitting or holding any interest in property in Oregon that may have mineral development potential. During the proposal development period and, if awarded the contract, during the contract period, the selected contractor shall maintain an arm's length relationship with all parties who are or could be interested in the rule making procedure before the Commission. The selected contractor is required to disclose all contacts, either to or by them, during the proposal process and the life of the contract.

II. INSTRUCTIONS FOR PREPARATION OF PROPOSALS

A. General Instructions

Each proposer's submittal shall be prepared on standard 8 1/2-inch by 11-inch paper and limited to 50 pages, exclusive of resumes. Charts and spread sheets may be larger. Standard brochures are not to be included in the proposal. To be considered responsive, the proposal must be organized in the same order that the information is requested in Section III and clearly identified with appropriate headings. There should be no unnecessary attachments, enclosures, or exhibits.

B. Questions regarding the RFP may be directed to:

Department of Environmental Quality
Attention: Harold Sawyer, Inter/Intra Program Coordinator
811 S. W. Sixth Avenue
Portland, OR 97204
Telephone: (503) 229-5776

Questions will be received between the hours of 8:00 a.m. and 5:00 p.m. through February 28, 1992.

C. Number of Proposals to Submit, Deadline, Mail and Hand Delivery Addresses

Seven copies of the proposal must be submitted in a sealed package prominently marked: **"Confidential: Proposal for Technical Advice on Mining Rules"**. Proposals must be received by Mr. Sawyer at DEQ Headquarters, Portland, Oregon, no later that 4:00 p.m., Pacific Standard Time, March 10, 1992. Proposals will be time stamped upon arrival at DEQ. Telegraphic, telephonic facsimile, or telephone proposals will not be accepted. For hand or courier deliveries, the street address is The Executive Building, 811 SW Sixth Ave., 6th Floor, Portland, Oregon. The mailing address is:

State of Oregon
Department of Environmental Quality
Attention: Harold L. Sawyer (6th Floor)
811 SW Sixth Avenue
Portland, OR 97204

Any proposal or part thereof received after the designated time will not be considered.

The DEQ may reject any proposal not in compliance with all prescribed public bidding procedures and requirements, and may reject for good cause any or all bids upon a finding by the DEQ it is in the best interest to do so.

D. Changes in Proposals

Modification of proposals already received by DEQ may be made if they are received by DEQ prior to the scheduled deadline for proposal submission. All modifications must be made in writing over the signature of the proposer.

E. Public Disclosure of Information Contained in Proposals

Proposals received shall remain confidential until the written notice of award of the contract has been made to the successful proposer. Thereafter, all proposals submitted in response to this request shall be deemed public record as defined in ORS 192.410 (4). Any actual proposer to this request who is adversely affected or aggrieved by the Agency's award of the contract to another proposer shall have ten (10) calendar days from the date of the award to file a written protest to the notice of award. No protest shall be entertained that is submitted after this time period.

If the protest is not settled or resolved by mutual agreement, the Director of DEQ, or his designee, shall promptly issue a written decision on this protest.

In the event that a proposer desires to claim portions of its proposal as exempt from disclosure under the provisions of ORS 192.410 et seq., it is incumbent upon the proposer to identify those portions in the transmittal letter. The transmittal letter must identify the page and particular exception(s) from disclosure upon which it is making its claim. Each page claimed to exempt from disclosure must clearly be identified by the "CONFIDENTIAL" printed in bold print on the top of the page.

DEQ will consider a proposer's request(s) for exemption from disclosure; however, DEQ will make a decision predicated upon applicable laws. An assertion by a proposer that the entire proposal is exempt from disclosure will not be honored.

F. Incurring Costs

DEQ will not be liable for any costs associated with the preparation and presentation of a proposal submitted in response to this RFP.

III. CONTENTS OF PROPOSAL

The proposal shall address the information contained in the following paragraphs. The information shall be presented in the order presented below:

A. Description of Project Team.

This section shall include the following for the prime contractor and each subcontractor or team member: name, areas of expertise, and summary of proposed project roles and services to be provided in performance of this contract. Also, if applicable, include a brief history of the firm; size; financial background and capability.

Disclosure of potential conflicts of interest, must be made in this section. As described in Section G of Part I, a potential conflict of interest includes, but is not limited to, any involvement during the past five years with mining companies, mining industry groups, or environmental groups active in working on mining regulations and permitting or holding any interest in property in Oregon that may have mineral development potential. Proposing contractors shall clearly state: a) whether any such involvement produced a substantial portion of their income, and; b) their approach to assuring that results of this study would not be biased by any such prior involvement.

The name, address, and telephone number of one person to contact regarding the proposal shall be included.

MBE/WBE/ESB Participation:

The Department of Environmental Quality is committed to acting affirmatively to encourage and facilitate the participation of Emerging Small Businesses (ESB), Minority Business Enterprises (MBE), and Women Business Enterprises (WBE). All businesses which are to be counted as a minority, women, or emerging small business must be registered with the Office of Minority, Women's, and Emerging Small Business Enterprises. A list of firms may be obtained from that office by calling (503) 378-5651.

B. Description of Project Management Plan.

This section shall include the proposer's schedule and approach to responding to each of the questions listed in Section D of Part I. A description of project considerations and problems perceived by the proposer shall be identified. Communication methods within the proposer's project team and with the DEQ shall be discussed. Each proposer shall provide a list of proposed key personnel and their proposed office location during the contract period.

C. Description of Team Members Experience and Capabilities.

This section shall include relevant management and technical experience, and capabilities of the proposer and team members (firms). Briefly discuss your experience and capabilities in the following areas:

1. Regulatory Experience

Provide a description of demonstrated project experience in dealing with interpretation and compliance with environmental laws and regulations.

2. Scientific/Technical Knowledge

Provide a description of project experience which reflects knowledge and skills in the following scientific/technical areas. The proposal must address each area clearly and concisely.

- Liner technology, including design, installation, and repair.
- Chemical processing technology, including technology specifically related to cyanide destruction, recovery and reuse.

3. Project Experience

Provide names, addresses, and telephone numbers of professional references from no more than three different projects for which key personnel proposed for work on this contract have also performed.

The presentation of project experience in this section shall provide a clear description of the work involved. This description shall include a concise statement of prime and subcontractor roles and responsibilities on each of the projects listed. Each project described shall include references that can be checked by DEQ. All representative project descriptions provided shall include the month and year the project was completed, the location of the project, employing agency/firm, the name and telephone number of a knowledgeable contact person.

4. Personnel.

Submit resumes for each person identified to perform under this contract.

D. Project Budget.

IV. EVALUATION OF PROPOSALS

Each proposal will be reviewed and evaluated on the basis of the criteria listed below. A committee consisting of Department staff and one or more advisors external to the Department will make a recommendation to the Director of the Department. The Director will make the final determination on contractor selection.

A. Proposer's organizational (team) framework and relationship between the prime and subcontractors are defined and appropriate.

B. Approach to planning, organizing and managing this project to meet scope objectives and schedules.

C. Experience and capabilities to perform all scientific and technical phases of requested activities.

D. Project experience and reference responses.

E. Adequacy and expertise of project management and technical staff.

F. Conciseness, quality, clarity and thoroughness of the written proposal.

G. The approach to managing potential conflict of interest.

H. Price

The Department reserves the right to conduct interviews with selected proposers prior to making a final selection.

DEQ reserves the right to reject any or all proposals and to award the contract to the firm or firms which in DEQ's sole and absolute judgment, will best serve the needs of the state.

2/7/92
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INDEPENDENT CONTRACTOR CERTIFICATION STATEMENT *

State agency certifies the contracted work meets the following standards:

1. Contractor will provide labor and services free from direction and control, subject only to the accomplishment of specified results.
2. Contractor is responsible for obtaining all assumed business registrations or professional occupation licenses required by state or local law.
3. Contractor will furnish the tools or equipment necessary to do the work.
4. Contractor has the authority to hire and fire employees to perform the work.
5. Contractor will be paid on completion of the project or on the basis of a periodic retainer.

______________________________ ____________________
Agency Signature Date

Independent contractor certifies he/she meets the following standards as required by ORS chapters 316, 656, 657 and 670:

1. You filed federal and state income tax returns for the business for the previous year, if you performed labor or services as an independent contractor in the previous year.
2. You represent to the public that you are an independently established business by meeting <u>four</u> (4) or more of the following:

_____ A. You work primarily at a location separate from your residence, or work primarily in a specific portion of the residence, which portion is set aside as the location of the business.

_____ B. You have purchased commercial advertising, business cards, or have a trade association membership.

_____ C. You use a telephone listing and service separate from your personal residence listing and service.

_____ D. You perform labor or services only pursuant to written contracts.

_____ E. You perform labor or services for two or more different persons within a period of one year.

_____ F. You assume financial responsibility for defective workmanship or for service not provided as evidenced by the ownership of performance bond, warranties, errors and omission insurance or liability insurance relating to the labor or services to be provided.

Contractor
Signature ______________________________ Date ________________

Entity ______________________________

***Corporations are not required to complete this form.**

RULES PROPOSAL:

OREGON ADMINISTRATIVE RULES

CHAPTER 340

DIVISION 43

CHEMICAL MINING

GUIDELINES FOR THE DESIGN, CONSTRUCTION, OPERATION AND CLOSURE OF CHEMICAL MINING OPERATIONS

OAR 340-43-065	Guidelines for Design, Construction, and Operation of Heap-Leach Facilities
OAR 340-43-070	Guidelines for Disposal of Mill Tailings
OAR 340-43-075	Guidelines for Disposal or Storage of Wasterock, Low-Grade Ore and Other Mined Materials
OAR 340-43-080	Guidelines for Heap-Leach and Tailings Disposal Facility Closure
OAR 340-43-085	Post-Closure Monitoring
OAR 340-43-090	Land Disposal of Wastewater
OAR 340-43-095	Guidelines for Open-Pit Closure

PURPOSE

340-43-005

The purpose of these rules and guidelines is to protect the quality of the environment and public health in Oregon by requiring application of "... all available and reasonable methods...", Oregon Revised Statutes (ORS) 468.710, for control of wastes and chemicals relative to design, construction, operation, and closure of mining operations which use cyanide or other toxic chemicals to extract metals or metal-bearing minerals from the ore and which produce wastes or wastewaters containing toxic materials.

DEFINITIONS

340-43-010

Unless the context requires otherwise, as used in this Division:

(1) "Chemical process mine" means a mining and processing operation for metal-bearing ores that uses chemicals to dissolve metals from ores.

(2) "Department" means the Department of Environmental Quality.

(3) "Guidelines" means this body of rules contained in 340-43-045 through 340-43-100.

(4) "Positive exclusion of wildlife" means the use of such devices as tanks, pipes, fences, netting, covers and heap-leach drip-irrigation emitters or covered emitters.

(5) "Tailings" means the spent ore resulting from the milling and chemical extraction process.

PERMIT REQUIRED

340-43-015

(1) A person proposing to construct a new chemical mining operation, commencing to operate an existing non-permitted operation, or proposing to substantially modify or expand an existing operation shall first apply for, and receive, a permit from the Department. The permit may be an NPDES (National Pollutant Discharge Elimination System) permit if there is a point-source discharge to surface waters or a WPCF (Water Pollution Control Facility) permit if there is no discharge. Consideration may be given to site-specific conditions such as climate, proximity to water, and type of wastes to establish the final permit type and requirements for the facility.

(2) The permit application shall comply with the requirements of OAR Chapter 340, Divisions 14 and 45 and be accompanied by a report that fully addresses the requirements of this Division .

PERMIT APPLICATION

340-43-020

(1) The permit application shall fully describe the existing site and environmental conditions, with an analysis of how the proposed operation will affect the site and its environment. The Department shall, at a minimum, require the information specified for the DOGAMI consolidated application under Section 13, Chapter 735, 1991 Oregon Laws. The Department will also use the information contained in NEPA (National Environmental Policy Act), EA (Environmental Assessment), or EIS (Environmental Impact Statement) documents, if they are required by the project, as partial fulfillment of the requirements of this paragraph.

(2) The permit application shall, in addition to the information described in Paragraph (1) above, include the following information, unless the information has been otherwise submitted:

(a) Climate/meteorology characterization, with supporting data;

(b) Soils characterization, with supporting data;

(c) Surface water hydrology study, with supporting data;

(d) Characterization of surface water and groundwater quality;

(e) Inventory of surface water and groundwater beneficial uses;

(f) Hydrogeologic characterization of groundwater, with supporting data;

(g) Geologic engineering, hazards and geotechnical study, with supporting data;

(h) Characterization of mine materials and wastes which include, for example, overburden, waste rock, stockpiled ore, leached ore and tailings. Characterization of mine materials and wastes shall include, but not be limited to the following:

(A) Chemical and mineral analysis related to toxicity;

(B) Determination of the potential for acid water formation;

(C) Determination of the potential for long-term leaching of toxic materials from the wastes;

(i) Characterization of wastewater (quantity and chemical and physical quality) produced by the operation;

(j) Assessment of the potential for acid-water formation from waste disposal facilities, low-grade ore stockpiles, waste rock piles and for surface water or groundwater accumulation in open pits that will remain after mining is ended.

(3) Data submitted by the permit applicant should be based on analysis of the actual materials, when possible, or may be based on estimates from knowledge of similar operations and professional judgment.

PLANS AND SPECIFICATIONS

340-43-025

(1) A person constructing or commencing to operate a chemical process mine or substantially modifying or expanding an existing chemical process mine shall first submit plans and specifications to the Department for construction, operation and maintenance of the facilities intended for treatment, control and disposal of wastes.

(2) The Department shall approve the plans, in writing, before construction of the facilities may be started. The plans shall address all applicable requirements of this Division and shall include, but not be limited to, the following:

(a) A description of the facilities to be constructed, including tanks, pipes and other storage and conveyance means for processing chemicals and solutions and wastewaters;

(b) A management plan for control of surface water;

(c) A management plan for treatment and disposal of excess wastewater, including provisions for reuse and wastewater minimization;

(d) A facility construction plan including, as applicable, the design of low-permeability soil barriers, the type of geosynthetics to be used and a description of their installation methods, the design of wastewater treatment facilities and processes, a quality assurance plan for applicable phases of construction and a listing of construction certification reports to be provided to the Department;

(e) A preliminary closure plan;

(f) A preliminary post-closure monitoring and maintenance plan;

(g) A spill containment and control plan.

DESIGN, CONSTRUCTION, OPERATION AND CLOSURE REQUIREMENTS

340-43-030

(1) All chemical process and waste disposal facilitiesand facilities for mixing, distribution, and application of chemicals associated with on-site mining operations; ore preparation and beneficiation facilities; and processed -ore

disposal facilities shall be designed, constructed, operated and closed in accordance with the guidelines contained in this Division.

(2) A groundwater monitoring plan shall be submitted to, and be approved by the Department. Monitoring wells shall be installed for detection of groundwater contamination as required by OAR Chapter 340, Division 40, unless the hydrogeology of the site or other technical information indicates that an adverse impact on groundwater quality is not likely to occur.

(3) Alternative methods of control of wastes may be acceptable if the permit applicant can demonstrate that the alternate methods will provide fully-equivalent environmental protection. The burden of proof of fully-equivalent protection lies with the permit applicant.

(4) The Department may, in accordance with a written compliance schedule, grant reasonable time for existing facilities to comply with these rules.

EXEMPTION FROM STATE PERMIT FOR HAZARDOUS WASTE TREATMENT OR DISPOSAL FACILITIES

340-43-035

(1) The state hazardous waste program requires a permit for the "treatment", "storage" or "disposal" of any "hazardous waste" as identified or listed in OAR Chapter 340, Division 101 from the Department, prior to the treatment and disposal of wastes. Permitting requirements can be found in OAR Chapter 340, Division 105, Hazardous Waste Management.

(2) However, any operation permitted under this Division, which would otherwise require the neutralization or treatment of hazardous waste and would require a permit pursuant to OAR Chapter 340, Division 105, shall be exempt from the requirement to obtain such hazardous waste treatment permit.

(3) All mined materials disposed of under this Division shall pass Oregon's hazardous waste rule criteria or they will be considered a state hazardous waste and must be disposed of accordingly.

GUIDELINES FOR THE DESIGN, CONSTRUCTION, OPERATION AND CLOSURE OF CHEMICAL MINING OPERATIONS

PURPOSE

340-43-040

(1) This Division establishes criteria for the design, construction, operation and closure of chemical mining operations and supplements the provisions of OAR 340-43-005 through OAR 340-43-035.

(2) Any disapproval of submitted plans or specifications, or imposition of requirements by the Department to improve existing facilities or their operation will be referenced when appropriate, to applicable guidelines or rules.

GENERAL PROVISIONS

340-43-045

(1) Facilities permitted under either a WPCF or NPDES permit shall not discharge wastewater or process solutions to surface water, groundwater or soils, except as expressly allowed by the permit.

(2) Facilities subject to these rules shall not be sited in 100-year floodplainsor wetlands. A buffer zone (a minimum of 200 feet wide) shall be established between waste disposal facilities and surface waters.

(3) All chemical conveyances (ditches, troughs, pipes, etc.) shall be equipped with secondary containment and leak detection means for preventing and detecting release of chemicals to surface water, groundwater or soils.

(4) Acid water accumulation in open pits resulting from the mining operation must be prevented by appropriate mining practices, by measures taken in the closure process, or be treated to control pH and toxicity, for the life of the pit.

(5) Construction of surface impoundment liner systems shall conform generally to the principles and practices described in <u>EPA/600/2-88/052, Lining of Waste Containment and Other Impoundment Facilities, September 1988</u>.

(6) The Department may require the permittee to hire a third-party contractor to perform the functions set forth below. Selection of the contractor shall be subject to Department approval.

(a) Review and evaluate the design and construction specifications of all mined-materials disposal facilities permitted under this Division for functional adequacy and conformance with Department requirements. The Department shall not approve construction of the disposal facilities until the design and construction specifications have been evaluated.

(b) Monitor the course of construction of all mined-materials disposal facilities for compliance with the approved design and construction specifications. The third-party contractor shall regularly document the progress of construction and the Department shall require the permittee to take corrective action if construction does not satisfactorily conform to the approved design and construction specifications.

CONTROL OF SURFACE WATER RUN-ON AND RUN-OFF

340-43-050

(1) Surface water run-on and run-off shall be controlled such that it will not endanger the facility or become contaminated by contact with process materials or loaded with sediment. The control systems shall be designed to accommodate a 100-year, 24-hour storm event, or any other defined climatic event that is more appropriate to the site, and be placed so as to allow for restoration of the natural drainage network, to the maximum extent practicable, upon facility closure.

(2) All mined materials shall be properly placed and protected from surface water and precipitation so as not to be eroded and contribute sediment to site stormwater run-off or to otherwise contaminate surface water.

PHYSICAL STABILITY OF RETAINING STRUCTURES AND EMPLACED MINE MATERIALS

340-43-055

(1) Permit applicants must demonstrate to the Department that the design of chemical processing facilities and waste disposal facilities is adequate to ensure the stability of all structural components of the facilities during operation, closure and post closure.

(2) Retaining structures, foundations and mine materials emplacements shall be designed by a qualified, registered professional and be constructed for long-term stability under anticipated loading and seismic conditions.

(3) Temporary structures and materials emplacements may, with written approval from the Department, be constructed to a lesser standard if it can be shown that they pose no, or minimal, threat to public safety or the environment.

PROTECTION OF WILDLIFE

340-43-060

(1) Wildlife shall be positively excluded from contact with chemical processing solutions and wastewaters containing chemicals.

(2) The Department may waive the positive exclusion requirement if the Oregon Department of Fish and Wildlife (ODF&W) certifies to the Department that the project is designed such that it will adequately protect wildlife.

GUIDELINES FOR DESIGN, CONSTRUCTION, AND OPERATION OF HEAP-LEACH FACILITIES

340-43-065

(1) This paragraph applies to heap-leach facilities using dedicated, or expanding, pads. Heap-leach facilities using on-off, reusable pads may require variations from these rules; they shall be approved on a case-by-case basis by the Department.

(2) The heap-leach facility (pad and associated ponds, pipes and tanks) shall be sized to prevent flooding of any of its components.

(3) TABLE 1 of this Division establishes minimum capacity-sizing criteria for the leach-pad and ponds. The pad and ponds may be designed to act separately or in conjunction with each other to obtain the required storage volumes. Other design criteria may be used, with Department approval, if local conditions warrant. The best available climatic data shall be used to confirm the critical design storm event and estimate the liquid levels in the system over a full seasonal cycle. The liquid mass balance may include provision for evaporation.

(4) The heap-leach pad liner system shall be of triple liner construction with between-liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible-membrane middle and top liners of suitable synthetic material separated by a minimum of 12 inches of permeable material (minimum permeability of 10^{-2} cm/sec);

(c) A leak-detection system between the synthetic liners capable of detecting leakage of 400 gallons/day-acre within ten weeks of leak initiation.

(5) The processing-chemical pond liners shall be of triple liner construction with between-liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible-membrane middle and top liners of suitable synthetic material separated by a permeable material (minimum coefficient of permeability of 10^{-2} cm/sec);

(c) A leak detection system between the synthetic liners capable of detecting leakage of 400 gallons/day-acre, within ten weeks of leak initiation.

(6) Emergency ponds may be constructed as an alternative to larger pregnant and barren ponds. The emergency pond may be constructed to a lesser standard, with the limitation that it is to be used only infrequently and for short periods of time. The Department will specify reporting and use limitations for the ponds in the permit. A between-liner leak detection system is not required for the emergency pond.

(7) The emergency-pond liner shall be of composite construction consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10^{-6}cm/sec) with a minimum thickness of 12 inches, and

(b) A single flexible-membrane synthetic top liner of suitable material.

(6) The heap-leach pad shall be provided with a process chemical collection system above the upper-most liner that will prevent an accumulation of process chemical within the heap greater than 24 inches in depth.

(7) The permittee shall prepare a written operating plan for safe temporary shut-down of the heap-leach facility and train employees in its implementation.

(8) The permittee shall respond to leakage collected by the heap-leach and processing-chemical storage pond leak-collection systems according to the process defined in TABLE 2.

(9) The permittee shall determine the acid-generating potential of the spent ore by acid\base accounting and other appropriate static and dynamic laboratory tests. If the spent ore is shown to be potentially acid generating under the conditions expected in the heap at closure, the permittee shall submit a plan for acid correction for Department approval prior to loading the heap.

GUIDELINES FOR DISPOSAL OF MILL TAILINGS

340-43-070

(1) Mill tailings shall be treated by cyanide removal and re-use prior to disposal to reduce the amount of cyanide introduced into the tailings pond. Chemical oxidation or other means shall be additionally used, if necessary, prior to disposal to reduce the WAD cyanide level in the liquid fraction of the tailings. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak-acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm.

(2) (Deleted)

(3) The permittee shall determine the potential for acid-water formation from the tailings by means of acid-base accounting and other suitable laboratory static and dynamic tests. If acid formation can occur, basic materials shall be added to the tailings in the amount of three (3) times the acid formation potential or to give a net neutralization potential of at least 20 tons of $CaCO_3$ per 1000 tons of tailings, whichever is greater, before placing tailings in the disposal facility.

(4) The disposal facility shall be lined with a composite double liner consisting of a flexible-membrane synthetic top liner in tight contact with an engineered,

stable, soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) having a minimum thickness of 36 inches.

Construction of the liner shall generally follow the principles and practices contained in EPA/600/2-88/052, "Lining of Waste Containment and Other Impoundment Facilities, September, 1988.

(5) The disposal facility shall be provided with a leachate collection system above the liner suitable for monitoring, collecting and treating potential acid drainage.

GUIDELINES FOR DISPOSAL OR STORAGE OF WASTEROCK, LOW-GRADE ORE AND OTHER MINED MATERIALS

340-43-075

The permittee shall determine the acid-producing and metals-release potential of the wasterock, low-grade ore or other mined materials by acid/base accounting and other appropriate static and dynamic laboratory tests. If the mined materials are shown to be potentially acid forming, or capable of releasing toxic metals, the permittee shall submit a plan for correction and disposal for Department approval prior to permanently placing the materials.

GUIDELINES FOR HEAP-LEACH AND TAILINGS DISPOSAL FACILITY CLOSURE

340-43-080

(1) The waste disposal facilities shall be closed under these rules in conjunction with the reclamation requirements of DOGAMI (Oregon Department of Geology and Mineral Industries).

(2) An up-dated closure plan and post-closure monitoring and maintenance plan shall be submitted to the Department by the permittee at least 180 days prior to beginning closure operations or making any substantial changes to the operation. The closure plan must be compatible with DOGAMI's reclamation plan and may be part of it.

(3) Chemical conveyances (ditches, troughs, pipes, etc.) not necessary for post-closure monitoring shall be removed. The secondary containment systems shall be checked before closure for process-chemical contamination, and contaminated soil or other materials, if any, shall be removed to an acceptable disposal facility.

(4) Closure of the heap-leach facility.

(a) The heap shall be detoxified over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The WAD cyanide concentration in the rinsate shall be no greater than 0.2 ppm.

(b) Following detoxification as defined in (a) above, the heap shall be closed in place on the pad by covering the heap with a cover designed to prevent water and air infiltration. The cover should consist, at a minimum, of a low-permeability layer and suitable drainage and soil layers to prevent erosion and damage by animals and to sustain vegetation growth, in accordance with DOGAMI's reclamation rules.

(c) The ponds associated with the heap shall be closed by folding in the synthetic liners and filling and contouring the pits with inert material. Residual sludge may be disposed of in one of the on-site waste disposal facilities, provided it meets the criteria for such wastes in these guidelines. The process chemical collection system of the heap shall be maintained in operative condition so that it can be used to monitor the amount and quality of infiltrated water, if any, draining from the heap.

(5) The tailings disposal facility shall be closed by covering with a composite cover designed to prevent water and air infiltration and be environmentally stable for an indefinite period of time. Maximum effort shall be made to isolate the tailings from the environment. Construction of the cover shall generally follow the principles and practices contained in EPA/530-SW-89-047, Technical Guidance Document -- Final Covers on Hazardous Waste Landfills and Surface Impoundments.

POST-CLOSURE MONITORING

340-43-085

(1) The Department may continue its permit in force for thirty (30) years after closure of the operation and will include permit requirements for periodic monitoring to determine if release of pollutants is occurring.

(2) Monitoring data will be reviewed regularly by the Department to determine the effectiveness of closure of the disposal facilities. The Department will consult with DOGAMI on release of security funds that would otherwise be needed to correct problems resulting from ineffective closure.

LAND DISPOSAL OF WASTEWATER

340-43-090

(1) To qualify for land disposal of excess wastewater, the permit applicant shall demonstrate to the Department that the process has been designed to minimize the amount of excess wastewater that is produced, through use of water-efficient processes, wastewater treatment and reuse, and reduction by natural evaporation. Excess wastewater that must be released shall be treated and disposed of to land under the conditions specified in the permit.

(2) A disposal plan shall be submitted as part of the permit application that, at a minimum, includes:

(a) Wastewater quantity and quality characterization;

(b) Soils characterization and suitability analysis;

(c) Drainage and run-off characteristics of the site relative to land application of wastewater;

(d) Proximity of the disposal site to groundwater and surface water and potential impact;

(e) Wastewater application schedule and water balance;

(f) Disposal site assimilative capacity determination;

(g) Soils, surface water and groundwater monitoring plan;

(h) Potential impact on wildlife or sensitive plant species.

(3) The Department will evaluate the disposal plan and set site-specific permit conditions for the wastewater discharge.

GUIDELINES FOR OPEN-PIT CLOSURE

340-43-095

(1) Open pits that will be left as a result of the mining operation shall be assessed prior to, and following, mining operations for the potential to contaminate

water to the extent that it might not meet water-quality standards due to build-up of acid or toxic metals.

(2) If the Department finds that the potential for water accumulation in the pit(s) exists, the permit applicant shall submit a closure plan for the pit that will address contamination prevention and possible remedial treatment of the water. The closure plan shall, at a minimum, examine the following alternatives:

(a) Avoidance, during mining, of acid-generating materials that can be left in place, rather than being exposed to oxidation and weathering;

(b) Removal from the pit and disposal, during or after the mining operation, of residual acid-generating materials that would otherwise be left exposed to oxidation and weathering;

(c) Protective capping in-situ of residual acid-generating materials;

(d) Treatment methods for correcting acidity and toxicity of accumulated water;

(e) Installation of an impermeable liner under ponded water to prevent groundwater contamination;

(f) Backfilling of the pit(s) above the water table to reduce oxidation of residual acid-generating materials.

TABLE 1

Heap-Leach Liquid Storage Criteria

Component	Pregnant-Solution Pond	Barren-Solution Pond
Operating Volume	Minimum necessary to maintain recirculation	Minimum necessary to maintain recirculation
Operational Surge	Anticipated draindown and rinse volume	Anticipated draindown and rinse volume
Climatic Surge	100-yr, 24-hr storm plus 10-yr snowmelt	100-yr, 24-hr storm plus 10-yr snowmelt
Safety Factor	2-ft dry freeboard	2-ft dry freeboard

TABLE 2

Required Responses to Leakage Detected from the Leach Pad

Leakage Category	Response
Zero leakage to 200 gal/day-acre	Notify the Department; increase pumping and monitoring
Leakage from 200 gal/day-acre to 400 gal/day-acre	Change operating practices to reduce leakage
Leakage in excess of 400 gal/day-acre	Repair leaks under Department schedule.

PROPOSAL TO PROVIDE TECHNICAL ADVICE ON MINING RULES

PREPARED FOR:

State of Oregon
Department of Environmental Quality

PREPARED BY:

TRC Environmental Consultants, Inc.

PROPOSAL NO: 11958-Q82-9202

March 9, 1992

TRC

TRC Environmental Consultants, Inc.

7002 South Revere Parkway, Suite 60
Englewood, CO 80112
(303) 792-5555

A TRC Company

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TRC

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Fax: (303) 792-0122

11958-Q82-9202 March 9, 1992

State of Oregon
Department of Environmental Quality
Attention: Mr. Harold L. Sawyer (6th Floor)
811 SW Sixth Avenue
Portland, Oregon 97204

RE: Proposal to Provide Technical Advice on Mining Rules

Dear Mr. Sawyer:

TRC Environmental Consultants, Inc. (TRC) is pleased to provide seven (7) copies of the enclosed Proposal to Provide Technical Advice on Mining Rules in response to your Department's February 7, 1992 Request for Proposal.

We feel that TRC is uniquely qualified to provide these services due to the combination of a number of factors, including the fact that TRC's proposed project team collectively possesses almost 100 years of professional experience in addressing the technical and regulatory issues facing proposed and active mining projects of varying magnitude; TRC has been successful in historically provided technical services in a professional manner to the regulatory community and industry clients alike; and TRC has assembled a project team that incorporates proven technical experts with a key team member, as Regulatory Affairs Liaison, that has recently been a major player in the development of similar mining rule programs in Minnesota and Maine. It is our opinion that, for this regulatory program to be a success, it will be necessary to incorporate, to the extent feasible, appropriate concerns reflecting the interests of all interested parties. To this end, we feel that it is important to establish credibility from the outset; therefore, we anticipate that TRC's Regulatory Liaison can skillfully define what aspects of the proposed technical approach incorporated in the proposal will be altered to reflect specific concerns to be identified by interested parties at the Initiation Meeting.

TRC appreciates the your consideration and the potential for the opportunity to provides these services. If you have any questions regarding the technical content or costing contained in this proposal, please do not hesitate to contact me directly at (303)792-5555.

Sincerely,

TRC ENVIRONMENTAL CONSULTANTS, INC.

James M. Beck

James M. Beck, P.E.
Manager, Hazardous Waste Investigation and Engineering

JMB:bb

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1.0 DESCRIPTION OF THE PROJECT TEAM

1.1 Introduction to TRC Environmental Consultants, Inc.

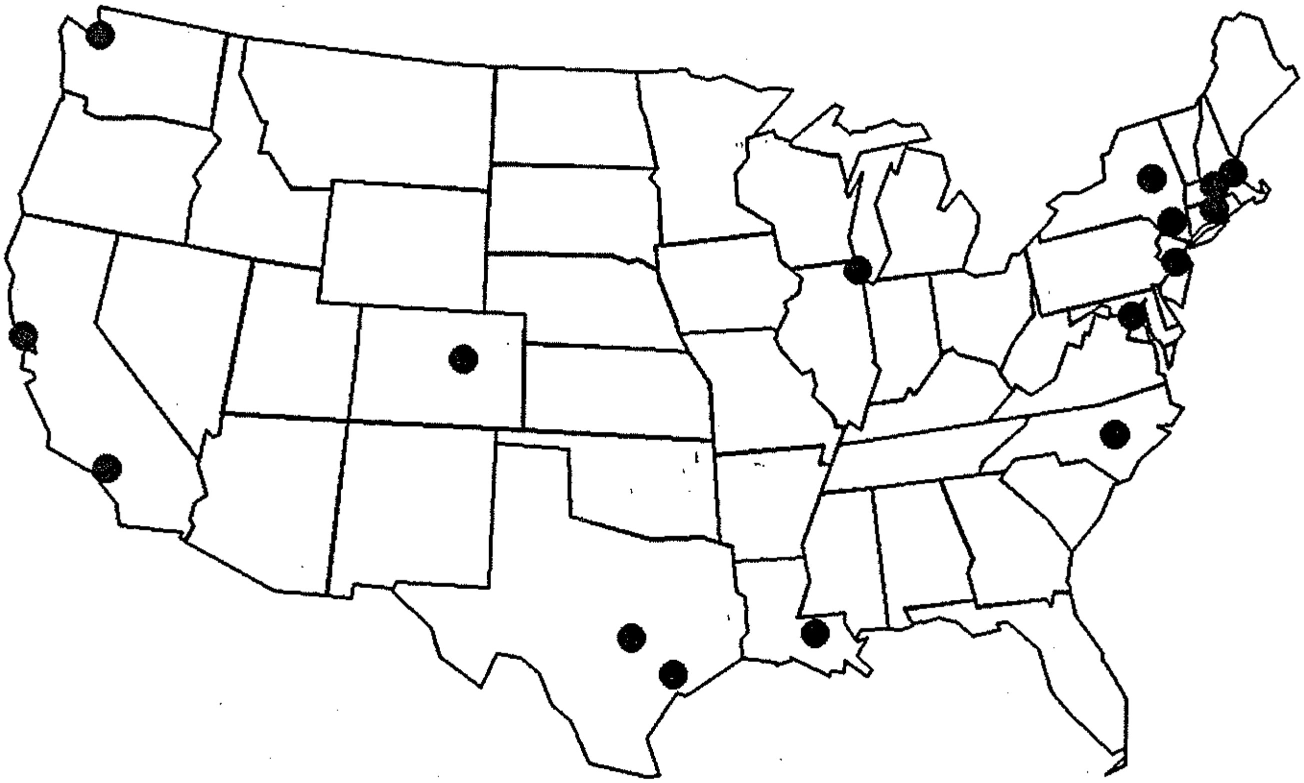
TRC Environmental Consultants, Inc. was founded in the early 1950's as an affiliate of the Travelers Insurance Company. Dedicated to environmental research and development, TRC Environmental Consultants, Inc. became an independent company in 1970 and has emerged as one of the nation's leading environmental consulting and engineering firms. Today, TRC Environmental Consultants, Inc. is a subsidiary of TRC Companies, Inc., a publicly-held corporation listed on the New York Stock Exchange. Additional subsidiaries providing environmental technologies and services include Alliance Technologies Corporation and MIE, Inc. With a combined strength of over 550 environmental professionals in 16 offices located throughout the nation, the TRC companies provide a diverse governmental, municipal, and industrial client base with a full range of environmental consulting, engineering, and technology development services. TRC Companies, Inc. assists clients in identification and solution of complex environmental problems and in establishing and maintaining compliance within the constantly evolving regulatory framework. For over 30 years, the name TRC has been synonymous with "quality"; our primary goal is to provide our clients with practical and economic solutions to protect their business interests while contributing to enhanced environmental quality and public health and safety.

TRC Environmental Consultants, Inc. (TRC) provides governmental, municipal and private sector clients with state-of-the-art science, engineering, and regulatory consulting services in the areas of hazardous waste management, site investigation, remedial engineering, site clean-up, design of treatment and disposal facilities, air pollution control, toxic substance control, environmental health, and risk management/analysis. TRC has established a long-standing reputation for providing quality environmental consulting and engineering services including the development and application of hazardous waste technologies for CERCLA (Superfund) and RCRA sites, particularly in the areas of hazardous waste minimization and treatment technologies. TRC is recognized nationally for its expertise in technology assessment, pollution prevention, and the environmental licensing and permitting of incinerators. TRC is also an international leader in air pollution measurement technology, with instrumentation capable of instantaneously measuring particulates and fibers in the workplace for both worker health protection and cost efficient ventilation operation in a multitude of applications.

Recent uses have included monitoring of: asbestos removal operations; coal mine and foundry dust suppression; ventilation/exhaust fan efficiency; measurement of airborne particulate dispersal at hazardous waste sites during remedial efforts; and aboard the Space Shuttle to monitor in-flight cabin cleanliness.

Our national staff of over 600 environmental professionals includes disciplines such as civil, mining and geotechnical engineering; metallurgical, process and chemical engineering; geology; hydrogeology; meteorology; chemistry; environmental health; air pollution control engineering; wastewater engineering; economics; and data processing. TRC's nationwide network of sixteen offices (see Figure) provides locations in Austin, Texas; Baton Rouge, Louisiana; Chapel Hill, North Carolina; Chicago (Naperville), Illinois; Denver (Englewood), Colorado; Houston, Texas; Los Angeles (Mission Viejo), California; Lowell, Massachusetts; New York, New York; Reston, Virginia; San Francisco (Petaluma), California; Seattle (Mountlake Terrace); Somerset, New Jersey; Troy, New York; Washington; and Windsor, Connecticut (Corporate Headquarters). TRC's gross revenues in 1991 were approximately $47 million, up from $42 million in 1990.

TRC COMPANIES , INC.



NATIONWIDE OFFICES

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Los Angeles, CA (714) 581-6860	Chapel Hill, NC (919) 968-9900	Bedford, MA (617) 275-5414
Lowell, MA (508) 970-5600	Chicago, IL (708) 505-8822	Baton Rouge, LA (504) 992-7761
New York, NY (212) 349-4616	Houston, TX (713) 371-3300	Reston, VA (703) 318-7757

TRC Services in the Mining and Minerals Processing Sector

TRC's multi-disciplinary staff of engineers and scientists offers a diverse and comprehensive range of environmental services to meet the particular needs of Mining and Minerals Processing clients. The Denver office of TRC is divided into divisions, headed by senior personnel with extensive mining experience, providing primary services in the following areas:

- *Remedial Engineering/Tailings and Waste Management*
- *Process Engineering and Wastewater Treatment*
- *Site Investigation*
- *Risk Management*

A brief description of the services provided by each division is described below. More detailed statements of qualification are available for each division.

1.1.1 Remedial Engineering/Tailings and Waste Management

TRC engineers have special expertise in both remediation of contamination problems and design of new treatment and disposal facilities. With direct experience working in and with the mining industry, they understand the importance of developing practical and economic solutions that are compatible with site or plant operations, while still achieving environmental control objectives.

Remedial engineering projects include CERCLA technical support, remining and reprocessing of mine wastes and tailings, stabilization and reclamation of tailings impoundments, control of seepage and groundwater contamination from tailings ponds, heap leach operations, slag piles, and waste rock dumps; repairs to leaking liners and impoundments; design of caps and other systems to prevent leaching of wastes; treatment and disposal of secondary recovery wastes; control of surface water contamination; and clean-up of contaminated soils. New facilities design includes: development of remining and reprocessing operations, tailings impoundments, heap leach facilities, slag piles and monofills, waste rock dumps, wastewater treatment lagoons, sedimentation ponds, and surface water diversions and control structures.

Groundwater contamination controls designed and implemented by TRC engineers include tailings stabilization and cover systems, geomembrane, compacted clay, and admix liners, geomembrane and soil caps for waste piles, groundwater recovery wells and interceptor drains, slurry walls and groundwater diversions, groundwater treatment systems, and injection wells.

TRC specializes in the fatal flaw analysis of environmental concerns at mining and mineral processing facilities. TRC staff can clearly identify these concerns and provide the unique and specialized perspective necessary for the engineering of solutions to problems while minimizing impacts and disruptions to ongoing or proposed operations.

1.1.2 Process Engineering and Wastewater Treatment

The solution to the high costs and potential environmental problems related to mining and process discharges is often an improved wastewater treatment system. TRC wastewater, process, and chemical engineers evaluate existing treatment plants and look for ways to optimize the system, reduce waste volumes, and better control effluent concentrations. In many cases, a single site visit and review of monitoring data can result in recommendations that help meet treatment standards and lower costs. If necessary, bench tests and pilot tests can be designed and run by TRC or the client to select optimum additives and processes. TRC engineers have extensive experience with multi-media evaluation and treatment of metals, cyanides (including process cyanide detoxification), organic and solvent wastes, acids, sludges, and leachates.

TRC's Denver office has been involved in development of innovative technologies for treatment of mine waste rock and tailings through processes resulting in metal recovery accompanied by a reduction in toxicity characteristics. Additionally, TRC recently reviewed innovative treatment technologies in foreign countries as part of an EPA Superfund research program, and has written five technical resource documents on hazardous waste treatment for application at Superfund sites.

1.1.3 Site Investigation

TRC has performed hundreds of investigations at commercial and minerals processing sites across the country, ranging from multi-year investigations at major CERCLA (Superfund) sites to one day investigations for routine environmental assessments. Depending on project needs, TRC can sample and take field measurements of groundwater and surface water, waste rock acid generating potential, sediments, soils, vegetation, ambient air, stack emissions, soil gas, asbestos, PCB's, and RCRA waste materials associated with routine mine operations.

TRC professionals work with clients to identify needs and limit investigation costs. At active mines, whenever possible, environmental investigations are coordinated with exploratory work to reduce the number of drill holes and cores. Air photos and geophysical techniques are used to cover large areas efficiently and rapidly. Sound geologic interpretation of formations and understanding of mine workings further limit the need for and costs of expensive drilling operations.

TRC personnel have the training, experience, and equipment to deal with a wide range of substances, including heavy metals, cyanide, radioactive materials, chlorinated solvents, creosote, petroleum hydrocarbons, pesticides, nutrients, pathogens, and a variety of other organic and inorganic compounds. Data evaluation tools include two and three-dimensional groundwater flow computer models; geochemical speciation models; and a variety of programs for aquifer analyses.

1.1.4 Risk Management

The objectives of environmental risk management include minimizing the risk of incidents causing environmental impact and liability, ensuring compliance with environmental regulations, and cost-effective management of wastes and environmental programs. TRC provides a wide range of services to meet these goals, including:

- regulatory analysis
- environmental compliance audits
- environmental property conveyance assessments
- risk assessment and health impact studies
- underground storage tank management programs
- emergency response planning and evaluation

1.2 Proposed Project Management and Technical Expert Team

TRC has assembled a team of regulatory development and technical experts to evaluate the DEQ's proposed mining rules. These specialists bring extensive experience specific to the technical concerns identified in the Oregon DEQ mining rule development process. TRC's proposed project organization is shown on Figure 1. Brief descriptions of project personnel and individual project roles are provided, following.

PROJECT MANAGER: James M. Beck, P.E.

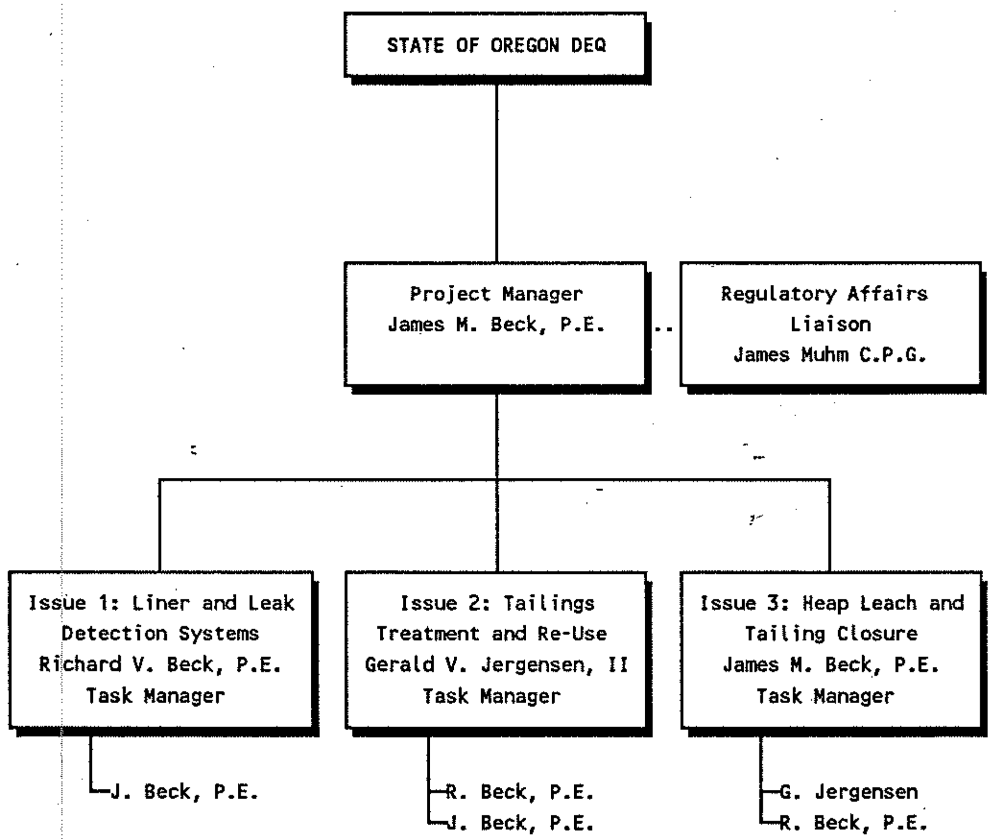
Mr. Beck will serve as project manager, and will be responsible for providing overall direction related to project technical issues, in addition to responsibilities for maintaining project budget and schedule objectives. As project manager, he will have the authority to commit TRC resources to meet those objectives, and will be the designated contact for this project.

Mr. Beck is a Registered Professional Engineer with fifteen years experience in mining and environmental engineering. He holds a B.S. degree in Mining Engineering from the Michigan Technological University (1977) and has completed studies toward an M.B.A. degree at the University of Colorado. He has extensive experience in the design and evaluation of heap leach facilities; cyanide destruction; liner, cap and cover systems; and in heap leach and tailing facility closure and site reclamation. This experience has been gained through approximately five years previous employment with Anaconda Copper Company in addition to employment as a mining and environmental consultant for the past ten years. His recent experience has included technical critique and comment on a number of proposed mine waste regulatory programs.

REGULATORY AFFAIRS LIAISON: James R. Muhm, CPG

Mr. Muhm will serve as regulatory affairs liaison, and will be responsible for coordination of technical presentations and discussions during the Project Initiation Meeting, as well as coordination of the presentation format for final report findings. His regulatory and public affairs background, coupled with a technical educational background will help to establish a

Figure 1: Project Organization
Oregon DEQ Technical Advice on Mining Rules



TRC

credible communication flow between interested parties and the technical consultant for this sensitive rulemeking review process.

Mr. Muhm is a Certified Professional Geologist with over forty years experience in regulatory affairs and community relations. He holds a B.S. degree in Geology from the University of Wyoming (1950). He is skilled and experienced in working on mining rule development programs, having recently been a major participant in a cooperative rulemaking effort under contract to the state of Minnesota. His experiences on that effort, culminating in the 1990 publication of "The Report on the Mining Simulation Project (Non-Ferrous Mineral Project)" entailed a comprehensive, cooperative effort between representatives of the environmental community, the mining industry, the Minnesota Department of Natural Resources, and the Minnesota Pollution Control Agency. Central to the study was testing of the regulatory program on three hypothetical mining developments in environmentally sensitive areas; consensus based conclusions were reached on aspects of all major issue areas, two of which focused on issues of importance to the Oregon rule making effort, water quality concerns and closure/post-closure design issues. He was subsequently engaged in a similar regulatory development program under contract to the state of Maine, for development of a statewide non-ferrous metallic mining regulatory program.

TASK MANAGER - LINER AND LEAK DETECTION SYSTEMS: Richard V. Beck, P.E.

Mr. Beck will serve as Task Manager for evaluation of liner system design criteria and in addition, will provide support on geotechnical aspects of the tailing and heap leach treatment evaluation as well as the tailing and heap leach closure task. As a geotechnical engineer, he has extensive experience in the design and construction of mining and solid waste facilities, including all aspects of liner and leachate collection systems, tailing impoundment facilities, and cap and cover systems for facility closure.

Mr. Beck is a Registered Professional Engineer with over fifteen years experience in all aspects of solid waste management facility geotechnical design and construction. He holds a B.S. degree in Physics from Elmhurst College (1975), a B.S. degree in Civil Engineering from Tri-State

University (1977), and an M.S. in Civil Engineering (Geotechnical) from the University of Colorado (1983).

TASK MANAGER - MILL TAILINGS TREATMENT: Gerald V. Jergensen, II

Mr. Jergensen will serve as Task Manager for evaluation of mill tailings treatment through cyanide removal and re-use and evaluation of geochemical transport mechanisms relating to metals and acid generating potential. As a mineral processing engineer, Mr. Jergensen has extensive experience in process chemistry and design and evaluation of heap leaching and tailing treatment operations.

Mr. Jergensen holds a B.S. degree in Minerals Engineering from the Colorado School of Mines (1965), and an M.B.A. degree from the University of Colorado (1972). He serves as an adjunct professor of Metallurgy at the Colorado School of Mines.

TASK MANAGER- HEAP LEACH AND TAILING FACILITY CLOSURE: James M. Beck, P.E.

Mr. Beck will serve as Task Manager for evaluation of heap leach and tailing facility closure criteria. He has extensive experience in the design of cap and cover systems for closure of heap leach pads and tailing impoundments. In addition, as an environmental consultant, he has been involved in the design and technical evaluation of a number of low-level radioactive waste disposal facilities incorporating earthen cover systems. One of the more critical aspects of radioactive waste cover system designs is longevity, or cover system performance over time, which also appears to be a central issue in the Oregon rule making effort.

A brief synopsis of Mr. Beck's credentials is provided above.

Due to the inter-relationship of many components in these technical issues, it is anticipated that all team members will perform in a support role on other Task issues. Complete resumes for each individual are provided in Section 3.0.

1.3 Disclosure of Conflicts of Interest

TRC has no significant identifiable conflicts of interest pertaining to this effort. TRC has historically provided professional consulting services to regulatory agencies and industry clients alike, while always striving to mitigate potential conflicts of interest. This has generally been accomplished through keeping regulatory agency assignments restricted to roles similar to the subject study, i.e. regulatory development guidance, regulatory review, etc., as opposed to functioning in a clearly defined enforcement role. TRC has historically performed significant proportions of professional services to mining (and other) industry clients, however, we are not able to identify any direct conflicts with respect to being under contract or other influence associated with: a.) Direct proponents of mining project development within Oregon; b.) Mining companies, mining industry groups, or environmental groups active in working on mining regulations and permitting in Oregon; or, c.) Entities holding direct interest in property in Oregon.

As indicated, TRC has historically performed professional services to the mining industry, and as such, professional staff have credentials and associations that would be not unexpectedly related to mining educational backgrounds, professional association affiliations, etc. TRC is of the opinion that due to the specialized technical expertise required to evaluate regulatory aspects pertaining to mining operations, it is precisely these attributes that will be essential in obtaining meaningful completion of the study. Nevertheless, TRC provides the following disclosures of what may be perceived as potential conflicts of interest by various interested parties. All of the following disclosures are related to project personnel, rather than corporate conflict potential, therefore, we would anticipate that perceived conflicts would not be significant.

1.) *James M. Beck, P.E.; Project Manager*, is an elected officer of the Colorado Mining Association (Vice Chairman of Environmental Affairs) and an elected member of the Board of Directors of that Association. Mr. Beck is also a member of the Northwest Mining Association and the Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers (SME-AIME).

2.) *James Muhm, C.P.G.; Regulatory Liaison* is a member of the Colorado Mining Association and selected Subcommittees of that Association. He is also a member of SME-AIME.

3.) *Gerald V. Jergensen, II; Task Manager*, was formerly an elected officer of the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers (Chairman of the Mineral Processing Division), and is an active member of that society.

1.4 MBE/WBE/ESB Participation

Due to the specialized nature of the technical evaluations required in this effort, TRC has selected primary project personnel based on their respective in-depth knowledge and technical expertise in the required area. TRC was unable to identify primary role subcontract relationships for this effort, however, every attempt will be made, where possible, to procure goods and services in support of this contractual effort, from MBE/WBE/ESB contractors.

2.0 DESCRIPTION OF PROJECT MANAGEMENT PLAN

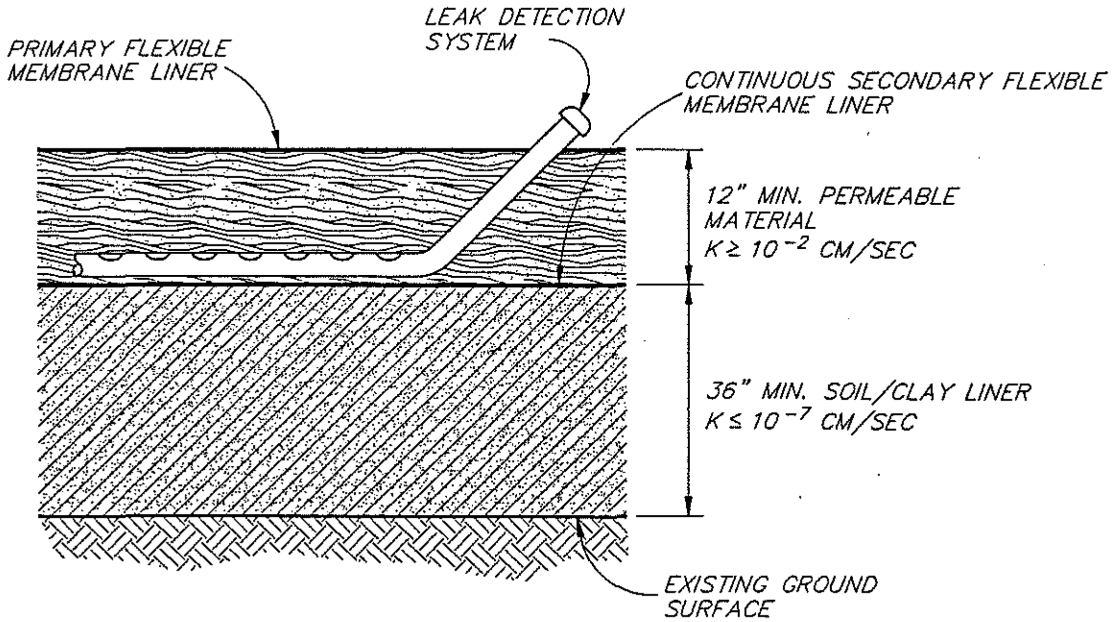
2.1 Issue #1: Liners, Leak Detection and Leak Collection Systems

General

TRC understands that the Environmental Quality Commission (EQC) wishes to evaluate and address four specific technical questions pertaining to liners, leak detection and leak collection systems. These questions are to be evaluated and addressed to determine if two specific liner systems under consideration will meet the stated policy objective of the EQC. In addition, the EQC wishes to determine if other liner systems would meet the stated policy objective. Simple cost comparisons are also to be provided for installation of the various liner systems. The two liner systems to be evaluated by the EQC are described as follows:

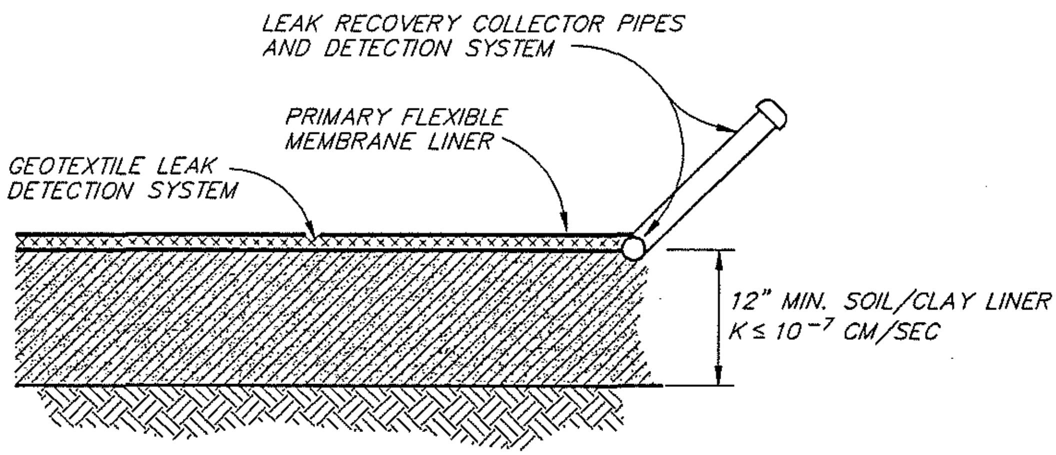
- A triple liner system (Figure 2A) with a leak detection system situated between the two continuous flexible membrane liners (FML's) located in 12 inches of permeable material possessing a minimum permeability of 10^{-2} cm/sec. The leak detection system shall be capable of detecting a leakage of 400 gallons per day per acre within a ten week period of leak initiation. The third liner shall consist of a minimum thickness of 36 inches of low permeability soil/clay possessing a maximum permeability of 10^{-7} cm/sec; TRC understands that this liner's system components are in conformance with proposed rule OAR 340-43-065(4).

- A composite two-liner system (Figure 2B), as proposed by the Oregon Mining Council, consisting of a low permeability (10^{-7} cm/sec) soil/clay bottom liner of minimum 12 inch thickness beneath the upper continuous FML. The two liners are proposed to be separated by a geotextile layer tied to collector pipes spaced at appropriate intervals to detect leakage within the prescribed 10-week period of time.



2.a) PROPOSED RULE 340-43-065(A) LEACH PAD LINER

(NOT TO SCALE)



2.b) OREGON MINING COUNCIL PROPOSED LEACH PAD LINER

(NOT TO SCALE)

PREPARED FOR:
STATE OF OREGON DEQ: TECHNICAL ADVICE ON MINING RULES

PREPARED BY:
TRC Environmental Consultants, Inc.

LINER SYSTEMS TO BE EVALUATED

FIGURE 2

TRC's proposed approach for evaluating and addressing each of the liner system questions is presented in the following subsections.

Approach

TRC has developed an approach which evaluates and addresses each of the four liner system questions, individually, utilizing TRC's knowledge and expertise, as well as published information and technical data currently available and related to each question. Sources of information and data anticipated for review include those publications available from the EPA and other regulatory agencies as well as the Geotextile Research Institute (GRI), the Society of Mining Engineers (SME), the American Society of Civil Engineers (ASCE), and other pertinent publications.

TRC's approach for evaluating and addressing each of the four liner system questions is as follows:

Question (1): Are each of the various liner systems proposed, technically feasible?

Approach to Question (1)

TRC proposes to address this question by evaluating for each of the liner systems their expected performance characteristics, feasibility of construction, and ability to be operated/maintained and repaired.

Performance Characteristics Evaluation

- Evaluation of the proposed leak detection and collection system to detect and recover 400 gallons/day/acre of leakage within 10 weeks of leak initiation.

- Evaluation of the deterioration potential of the leak detection and collection systems functionality due to clogging, increases in surface loading from heaped ore material and environmental factors with time.

- Evaluation of the ability, capacity and ease of operation of the leak detection and collection system to be utilized for remediation purposes in the event that a leak through the primary liner would occur.

- Evaluation of the use and functionality of the leak detection and collection system to identify location(s) of leakage within the primary liner, to minimize disturbance to the liner systems in the event repairs are necessary.

- Evaluation of the liner systems' abilities to comply with the permeability requirements as prescribed by EQC policy.

- Evaluation of geotechnical considerations with respect to each liner system including strength, stability, potential for slippage and settlement considerations.

- Evaluation of the liner system design with regard to providing sufficient factors of safety in the system design and operation in the event distress to the system occurs.

Construction Feasibility Evaluation

- Evaluation of those quality assurance/quality control (QA/QC) considerations that would be necessary for successful construction of each liner system. The evaluation would give indications of the level of complexity to be expected in constructing each liner system and the potential for problems arising due to the limitations and variances in the construction processes. This evaluation would indicate whether one system could be expected to be constructed more reliably than another system.

Operational/Maintenance/Repair Potential Evaluations

- Evaluation of the ease of operation maintenance and repair of the liner systems, including the leak detection and recovery systems.

- Evaluation of the ability of the liner systems to be expanded or be constructed in stages with ongoing ore deposition and pad expansion.

- Evaluation of the long term post closure maintenance considerations of the liner systems after operations have ceased as well as decommissioning considerations which may affect the liner systems' functionality.

Question (2): Will each of the various liner systems meet the stated EQC policy?

Approach to Question (2)

Based on the evaluations performed to address Question (1), potential and/or obvious "fatal flaws" in the liner systems may be identified with respect to complying with the stated EQC policy. Obvious fatal flaws will be considered just cause to show a liner system is in non-compliance with the stated policy objectives. Potential fatal flaws will be further investigated by developing situations or scenarios to test further the potential of the liner system(s) to be flawed. These situations would further test the system's performance, constructability, and operation/maintenance and repair capacities, depending on the component(s) of the system under scrutiny. Once the fatal flaw analysis is performed it will be determined whether or not a liner system meets the stated EQC policies.

Question (3): For those liner systems which will meet the stated EQC policy, what level of certainty would be assigned to each system?

Approach to Question (3)

Those liner systems which have been deemed as meeting the stated policy will be further analyzed with regard to their reliability. This analysis will involve ranking or rating the expected reliability of both the integrated and individual components of each liner system with respect to functionality, constructability, maintenance, operational ease and repair potential. A review of the literature to ascertain the reliability or level of certainty of similar liner systems will also be conducted to aid in the analysis. Based on the results of the rankings and appropriate weighting factors, a level of certainty will be assigned to each liner system.

Question (4): Are there other liner systems which will achieve this policy and what level of certainty for achieving this policy would be assigned to each?

Approach to Question (4)

Based on the review of the literature and product information literature, TRC will investigate the applicability of alternative liner systems, in addition to the two systems already considered. TRC will evaluate one (1) additional "best candidate" liner system to determine if it is in compliance with EQC policy. The evaluation and assignment of the level of certainty would be performed using the same methodology as carried out for the other two liners. The alternative liner would then be able to be compared to the other two liners due to utilization of similar evaluation procedures.

Simple Comparison of Typical Costs for Installation of Various Liner Configurations

TRC will provide estimated costs for installation of those liner systems evaluated, for comparative cost analysis. The estimates will include the material, equipment and labor costs to install each liner system only, on a per square foot or per square yard basis. Other associated costs such engineering and administrative fees, permitting fees and land use fees, etc. will not be considered as part of the estimate. It should be noted that the costs will not be used as part of the evaluation or ranking procedures to assign levels of certainty, but will be presented autonomously.

However, the costs may be useful for future financial or cost-benefit analyses since these analyses are not proposed to be considered as a part of this study.

2.2 Tailings Treatment to Reduce the Potential for Release of Toxics

The EQC commission intends that the toxicity and potential for long term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment.

Cyanide has been used in the gold mining industry for over 100 years. The chemistry and environmental fate of cyanide has probably been the subject of more research and literature than any other mining reagent. Cyanide solutions are also extensively used in industrial plating, metal washing and electronics manufacturing operations. Because of this widespread use, a number of methods have been developed for treating cyanide waste solutions.

Most of the treatment techniques involve destruction of cyanide, in solution, to achieve concentration standards as required by various water quality standards. Well known processes for chemical oxidation include alkaline chorination, hydrogen peroxidation and sulfur dioxide conversion. Each process is capable of reducing cyanide levels to the Federal drinking water standard of 0.2 mg/l. The selection of the actual process therefore becomes an engineering and financial decision.

Cyanide recovery and/or regeneration processes have also been applied with various levels of success. The most well-known process is known as AVR (Acidification-Volatilization-ReNeutralization). Other removal processes involve ion-exchange, chemical conversion and regeneration, solvent extractions and physical adsorptions. Biological oxidation technology is in development at the Bureau of Mines and a commercial biological oxidation process is being marketed by Homestake Mining Company.

This study will focus upon AVR technology. Chemical conversion and regeneration procsses will be reviewed and examined in more detail if a preliminary review indicates possible technical feasiblity.

The general approach will evaluate:

1. Potential processes;
2. Technical feasiblity;

3. Conditions required to meet 30 ppm std.;
4. Factors that favor or preclude commercial application;
5. Impact upon long-term cyanide or toxic metals release; and
6. Level of certainty (long-term industry and regulatory experience with technologies).

Removal technology will be compared to chemical oxidation methods to determine (or identify) alternatives that may effectively achieve the policy of the commission.

Question 1: Are removal and reuse technically feasible?

Approach

TRC proposes to address this question by identifying and describing one or more processes that remove cyanide from the tailings stream. TRC interprets "removal" to mean physical isolation from the liquid fraction of the tailings of soluble (and weak-acid-dissociable) cyanide.

TRC further assumes that "reuse" means the reintroduction of the "removed" cyanide compound into the process. However, sale for other beneficial use or disposal to a permitted TSD may be a possibility. TRC will conduct a review of mining industry practice and experience and reported research efforts. We will identify:

- Technical definition
- Pilot plant, semi-works and commercial experience with locations and references
- Required materials of construction and expected performance

Question 2: Do removal and reuse materially reduce the toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

TRC proposes to evaluate anticipated process performance of various cyanide removal and/or destruction methods. Evaluation of long term responses will depend upon information available from similar operations, if any. General conclusions from other gold mining operations will be applied to projections of future responses.

Question 3: What is the level of certainty to conclusions?

Level of certainty will be dependent upon information available, however TRC will attempt to compile actual operating data, if possible to enhance the level of certainty.

Question 4: Are there other tailings treatment technologies which will equally, or more effectively, achieve the policy of the EQC?

Chemical destruction methods may provide immediate, proven, technologies to achieve the EQC's goals. However, emerging technologies, in combination with recovery and reuse or destruction (such as bio-oxidation) may warrant evaluation.

2.3 Issue #3: Closure of Heap Leach and Tailings Facilities

General Overview

TRC understands that it is the EQC's intent to evaluate three particular aspects related to design of closure methodologies for heap leach or tailings facilities. Primarily, concerns are focused on the appropriateness of three specific proposed rules (Rule Numbers 340-43-080(4)(a); 340-43-080(4)(b); and 340-43-080(5)) which respectively incorporate the following provisions: 1.) Heap leach detoxification over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The weak acid dissociable (WAD) cyanide concentration in the rinsate shall be no greater than 0.2 ppm.; 2.) Heap leach closure by covering the heap with a cover designed to prevent water and air infiltration; and, 3.) Tailings disposal facility closure through installation of a composite cover system designed to prohibit water and air infiltration and be environmentally stable for an indefinite period of time. Evaluation of these three proposed rules will center on evaluating the effectiveness of detoxification (cyanide removal by rinsing) of the heap and covering of the heap and tailings facility to exclude air and water, materially reducing the likelihood of any release to the environment of toxic chemicals and metals contained in the heap over the long term.

Approach

TRC's approach to evaluating and addressing issues central to the above-described proposed rules will be heavily dependent on TRC staff knowledge, expertise, and experience in the design, implementation and/or installation of facility closures of a like or similar manner; review of published information and technical data currently available; and review of closure technologies currently employed in other states. As part of the latter, TRC will attempt to determine performance of closure technologies stipulated in other states, however, we would anticipate that limited data may be available due to the fact that very little is known about the long-term performance of such closure mechanisms. There are two primary reasons; first, because comprehensive closure criteria have only recently been applied statutorily, and secondly, heap leaching of precious metals generally did not play a major role in U.S. mining practices until as recently as 15 years ago. On the other hand, cyanidation has been utilized since approximately the turn of the century, and considerable knowledge has been gained as to the long-term effects of air and water intrusion into cyanide-laden tailings. The following are considered primary cover system evaluation criteria:

- Reduction of water input into heap from precipitation and snow melt;
- Reduction of dilution of Cn;
- Potential anaerobic condition and implication with respect to oxidation potential;
- Reduction in evaporation potential of more tightly held solution;
- Reduction in ability of CN gas or other gasses developed to be released from the heap;
- Increase in stress due to construction of cover and increased pore pressures and pressure gradients through liner to spread or disperse solution into environment;
- Effect of earthen liners versus synthetic liners and their viability over the long term, e.g. cracking, leaking UV radiation, shrinkage, expansion, etc.
- Constructability, reclamation, and erosion potential as well as maintenance of holes from animals, vegetation, etc. through cover.

TRC anticipates that it will be necessary, to establish a credible review, to separate the issues pertaining to residual cyanide, and toxic metals transport, when conducting a review of the proposed rules on heap and tailings closure. This is due to the fact that metals and cyanide compounds have different attenuation mechanisms and varying toxicity effects, both of which are dependent upon metallurgical processes employed, as well as numerous site-specific parameters.

Question (1): Are detoxification and covering (as prescribed in this rule) technically feasible?

Approach to Question (1)

TRC proposes to address this question through coordinated effort resulting from analysis of Issue Number (2) in combination with geotechnical examination of representative cover systems. Detoxification will be evaluated for prospective feasibility as the main emphasis in Issue Number (2), and findings resulting from that phase of the study will provide insight into the technical aspects of detoxification. Sufficient data is readily available from operating facilities as well as through research documentation to evaluate technical feasibility of rinse/rest cyclic detoxification. The primary emphasis on TRC's evaluation of detoxification feasibilty will therefore likely be related to evaluation of the target concentration level of 0.2 ppm WAD cyanide, within the context of achievability.

Cover system evaluation will be based on representative design criteria, with a perspective toward evaluation of the feasibility (practicality or desireability) of "preventing" water or air infiltration into the closed unit. We would anticipate that such an evaluation would involve an assessment of the field achievability of anticipated unit construction permeability coefficients and the relationship of those permeability coefficients to long term effectiveness. Long-term effectiveness assessment criteria would include, but not be limited to, climatic conditions (susceptability to degradation due to precipitation, drying, freeze/thaw, etc.), disturbance due to wildlife (vector) intrusion, and potential chemical alteration of cover materials. Geotechnical evaluation criteria would include considerations of the representative cover design(s) including strength, stability, potential for slippage, and settlement conditions.

Question (2): Do detoxification and covering (evaluated separately and together) materially reduce the likelihood of a release of toxic chemicals and metals to the environment?

Approach to Question (2)

TRC anticipates that this evaluation will be closely related to the activities and findings resulting from evaluation of Question (1), above. Once technical feasibility is established (assuming that it can be accomplished), evaluation of the two closure technologies can be carried out on a stand-alone basis as well as in combination with one another. Since the EQC is interested in specifically evaluating the likelihood of such technologies to "materially" reduce the likelihood of any release to the environment, TRC envisions that some effort will be required to more clearly evaluate the terms "materially", "release" and "environment", particularly for the evaluation of the tandom technology evaluation. It would seem appropriate to evaluate or define these terms within the context of commonly accepted definitions in recognized regulatory statutes pertaining to chemical constituents and/or contaminates identical or similar to those encountered in heap leaching and flotation processes (in the case of tailings). It will also be necessary to examine issues pertaining to exposure pathway and risk-related parameters, i.e., what constitutes an exposure of a significant "unacceptable" level versus an "acceptable" level. We would anticipate that this particular question will constitute an extremely sensitive issue when taken under consideration by all concerned parties, however, TRC is of the opinion that this approach is the sole, available objective approach. To assume statutory "zero-risk" criteria in combination with statutory imposed design criteria consistent with RCRA Subtitle C, will by definition "materially reduce the likelihood of any release to the environment", however, such an approach may (or may not) be totally warranted when considered within the context of the characteristics and types of contaminates involved. TRC therefore, would propose inclusion of such an analysis as part of the Question (2) issue, with the objective of utilizing information gained to objectively complete the analysis of Question (3), below.

Question (3): What is the level of certainty you give to the answers provided above?

Approach to Question (3)

TRC's approach to determination of the level of certainty in the answers to Questions (1) and (2) will be based on a probability/risk assessment weighting of the parameters involved. These parameters will include proposed statutory technical criteria, characteristics of the contaminates, and determined representative considerations pertaining to "indefinite" and "long-term". As discussed above, these considerations will be heavily dependent on interpretation of certain terminologies and/or definitions. As such, TRC will attempt to provide a determination of the level of certainty for the broad spectrum of design considerations, ranging from a technically conservative approach to a technically liberal approach.

Question (4): Are there other technologies which can equally or more effectively achieve the policy of the EQC?

Approach to Question (4)

TRC will attempt to identify and evaluate variants on the proposed technologies that are considered to be within the range of acceptability criteria to meet the EQC's objectives. To introduce entirely different technologies at this point in time would introduce another series of concerns to the regulatory promulgation process. Suffice it to say that it is highly likely that other technologies that may be introduced would be unproven, prototype technologies that would require a long term evaluation process, potentially negating the positive aspects of moving forward with effective and meaningful regulatory action at this time. While variations on the technologies currently under consideration are potentially applicable, broadening the focus on exploratory evaluations at this time would serve no beneficial purpose.

2.4 Public Meeting

Initiation Meeting

TRC anticipates that a single meeting of approximately on-half day's duration in the Portland area will be necessary to initiate the study and will serve as an effective technique to assure that a meaningful study will be conducted. The purpose of this meeting will be two-fold: to provide a discussion of the TRC approach; and to elicit comment from parties interested in the rulemaking proceeding. TRC will be interested in receiving first-hand comment on the proposed approach, to enable incorporation of concerns into the evaluative process. An information exchange will provide the mechanism for full understanding of the issues that may not be adequately addressed in the approach provided in this proposal. While it is premature at this time to determine content, TRC is of the opinion that such a meeting will be most beneficial if a brief summary of the intended approach is provided in advance of the meeting to all parties given notice. This will generally lead to more informed dialogue and lessen the potential for surprises to occur due to what may be perceived (rightfully or otherwise) as a "new" approach or different from what may be expected.

As stated in Section 1.0, TRC intends to incorporate a Public Relations Liaison into its project team. This strategy has been selected to ensure that the initiation meeting is carried out with a productive and positive demeanor. TRC is fully aware of the sensitivity of issues involved to the various parties to the proceedings, and is equally cognizant that any contractor selected for purposes of review will in all probability be suspect in the opinion of one or more parties. For this reason, we feel that it is critical to involve a professional public affairs liaison in the presentation process.

2.5 Logistical Considerations

2.5.1 Project Schedule

TRC proposes to conduct all task issue studies in a concurrent fashion. We anticipate no problem in complying with the project schedule as presented in the Request for Proposal, which incorporates the following dates:

- Participation in Public Meeting within fifteen (15) calendar days of contract execution.

- Draft written report submittal within forty-five (45) calendar days of contract execution.

- Return of a final report within fifteen (15) calendar days of receipt of comments from Oregon DEQ.

Based on the foregoing, TRC would project that, if contract finalization occurs on or before April 15, 1992, draft report submittal should occur on or about May 29, 1992, followed by the DEQ review/comment period. Allowing for a thirty (30) day review/comment period, TRC would be capable of delivering a final report document on or about July 17, 1992.

2.5.2 Work Location

With the exception of the Initiation Meeting to be held in Portland, Oregon (or another designated location to be determined), all work will be carried out in TRC's Denver, Colorado office. Designated contact for all communications regarding this proposal shall be James M. Beck, P.E., Manager, Hazardous Waste Investigation and Remedial Engineering, TRC Environmental Consultants, Inc., 7002 S. Revere Parkway, Suite 60, Englewood, Colorado 80112. Telephone and FAX numbers are (303) 792-5555 and (303) 792-0122, respectively.

2.5.3 *Communications*

TRC anticipates provision of brief weekly reports to the designated DEQ contract manager, incorporating discussion of work progress, budget status (expenditures to date versus projected budget), and other items as appropriate. Due to the nature of the effort, we would envision routine communications with the DEQ contract manager and technical representatives on a regular basis during the contract period. These may include written memoranda, telephone communications, or facsimile transmittal. TRC will maintain a log of all communications pertaining to this project. A compilation of communications logs will be provided upon DEQ request.

3.0 DESCRIPTION OF TEAM MEMBERS EXPERIENCE AND CAPABILITIES

3.1 Regulatory Experience

Specific team member information is provided in Section 1.2.

3.2 Scientific/Technical Knowledge

Specific team member information is provided in Section 1.2.

3.3 Project Experience

All project personnel have extensive regulatory project experience. James M. Beck, P.E., Project Manager, recently concluded the management and technical direction of a third party review of a major landfill expansion application under contract to El Paso County, Colorado. This review was conducted independently to assess the applicant's conformance with technical design criteria stipulated by the Colorado Department of Health to protect affected landowners from groundwater quality impact concerns. The review was completed in a manner that recommended additional investigations satisfactory to all parties.

In another example, he was a primary technical contributor to a third party independent review of the technical sufficiency of a proposed heap leach and mining operation in South Carolina.

Specific TRC project experience is provided herein under the section entitled "Experience".

3.4 Personnel

Resumes for each individual proposed to perform on this contract are provided herein.

4.0 PROJECT BUDGET

4.1 Project Budget by Task

TRC proposes to provide the above-described services (on a fixed cost basis) for the following cost:

Initiation Meeting (2 Persons)	
Direct Labor	$2,100
Other Direct Costs	2,000
Task I:	
Direct Labor	$6,000
Other Direct Costs	250
Task II:	
Direct Labor	$3,500
Other Direct Costs	250
Task III:	
Direct Labor	$3,500
Other Direct Costs	250
Report Finalization	$ 350
Project Management	250
TOTAL	$18,450

The following are representative project experience descriptions.

- *American Mining Congress - Industry Superfund Site Evaluations*

  TRC, under contract with the America Mining Congress (AMC), conducted a three-phased study of the 17 mining sites listed on the National Priorities List (NPL) and 14 additional mining sites nominated, but not ultimately listed. Phase I involved the review of each of the above sites, determination of the reasons for each site's listing cataloging the "Human Health" or environmental effects, and a review of mining and waste disposal practices at each site. Phase II was a detailed evaluation of mining operational and waste management practices that the mining industry used between 1800 and 1900, 1900 to 1965, and 1965 to the present. Phase III of the work involved the assessment of the Mitre model and its application to each site listed as well as the 14 sites nominated, but not actually listed on the NPL.

- *American Mining Congress - Health Risk Assessment of Mining Sites*

  TRC conducted a multi-phased contract addressing various health, toxicological, and risk issues relevant to mining sites on the National Priority List and their impact on the environment.

  The contract consisted of the evaluation of the 17 mining sites listed on the NPL and 14 mining sites nominated but not ultimately listed. The specifics of this work included risk assessment, pathway evaluation (ground water, surface water, air, and direct contact), toxicological and health effects, and ground water modeling. TRC is presently evaluating the health effects of the wastes associated with the mining industry through a program that will analyze and model the chemical transport in the environment and assess health effects and risk associated with the mining industry's waste management practices.

- *Confidential Client - Audit of Mining Operations and Review of Tailings Pond Control Systems - Wyoming*

  TRC performed an environmental audit of mining and ore processing facilities to determine whether regulatory obligations were being met. TRC engineers reviewed the methods used to control seepage from a large tailings pond and assessed the likelihood of long term environmental degradation. TRC was able to offer suggestions to assist with environmental compliance.

- *Confidential Client - Preliminary Evaluation of Methods to Control Seepage from Historical Tailings Impoundments - Missouri Lead Belt*

TRC was elected to select and evaluate practical methods for controlling seepage from tailings impoundments. TRC evaluated the constituents within the water emanating from the impoundments and identified the methods to be used for control. Selection of appropriate methods was based on cost, degree of treatment, and compatibility with the environment.

- *Historic Mining District - Oklahoma*

TRC served, on behalf of a client, on a technical committee advising the Governor's Task Force on the RI/FS on one of the first and largest NPL sites. The assignment included multi-year participation in the technical review of the workplans and investigation of a number of contractors and agencies, keeping the client informed of progress and problems, and technical input to achieve a practical and cost-effective solution to the remediation and control of acid mine drainage in one of the largest historic mining districts.

- *PRP Technical Support - Smuggler Mountain Superfund Site - Aspen, Colorado*

TRC has performed specific tasks to assist the Smuggler Mountain Superfund Site PRP's in selecting and ultimately implementing the most cost-effective approach to the site remedy, as specified by the US EPA Record of Decision for the site. Specifically, TRC carried out an engineering cost estimate for Operable Unit No. 1, to determine potential costs of the remedy, the effects of varying unit prices and soil volumes on overall costs and areas where cost savings could be realized. In addition, TRC inspected a boulder pile on the site and assessed the stability of the pile based on historic data and knowledge of rock pile stability. A demonstration of the integrity of the pile, allowing it to be left in place, could significantly reduce the cost of the remedy.

- *Confidential Client - Mine Tailings Remediation - Utah*

  TRC evaluated and coordinated a study for the removal of mine tailings that had migrated off-site and several miles along a stream channel. The study was conducted in accordance with the NCP for possible third-party cost recovery. The tailings contained elevated concentrations of heavy metals. The study was designed to remove the tailings based on visual characterization to reduce burdensome analytical costs.

- *Western Mining - Environmental Assessment - Colorado*

  TRC conducted an environmental assessment for an Australian mining company considering the purchase of an operating mine with acid mine drainage problems in southwestern Colorado. The principal concern centered on the fact that the facility owner had been named as third party defendant in a Natural Resources Damages Claim by the State of Colorado under CERCLA. It was determined that there was no technical basis for the operations at this property to adversely affect resources in the surrounding area subject to the law suit.

- *ASARCO, Inc. - Remedial Investigation/Feasibility Study for Metal Smelting and Refining Facility - Denver, Colorado*

  TRC is managing a major, multi-disciplinary environmental investigation for ASARCO at one of its smelting and refining facilities in Denver, Colorado. Subject of a $50 million plus lawsuit under CERCLA, the site covers over 90 acres with large slag and tailings deposits and has been in operation since 1886. TRC is directing the work of a team of hydrology, soils, vegetation, aquatics and environmental health consultants at the site, providing direct technical input, overseeing investigations, reviewing work product, developing work plans, and acting as official liaison with the Colorado Department of Health and their consultants. Investigations have included extensive groundwater contamination studies, water and sediment sampling in a several mile long segment of the South Platte River, soils and vegetation sampling and surveys in a two mile radius of the site, and ambient air quality monitoring. TRC staff were instrumental in helping ASARCO and their legal counsel reach agreement with the State on a cooperative study, thus reducing legal costs and ultimate investigation costs while allowing the client to retain control of the study.

TRC is also conducting a feasibility study to evaluate various remedial alternatives at the site, including slurry walls, interceptor drains, groundwater recovery wells, waste pile caps, on-site landfills meeting RCRA standards, and soil treatment.

- *Gold Fields Mining - Permit Applications - Colorado*

TRC performed initial permitting feasibility studies, and obtained the Exploration Permit for an underground precious metals mine in Eagle County, Colorado. The permit application included an analysis of the impact of exploration on soils, water, vegetation, and air quality. Additionally, TRC prepared an environmental assessment report which was subsequently reviewed and approved by the County Government.

- *Confidential Client - Develop a Cleanup Plan to Remove and Dispose of Process Wastes and Tailings from a Minerals Processing Facility - Wyoming*

TRC is developing a plan to remove process wastes and tailings from a minerals processing facility. The cleanup plan will organize and prioritize the proper disposition of materials on and from the site. Materials will be categorized according to their chemical characteristics and regulatory status. Appropriate disposal options and costs will be assessed. Regulatory considerations regarding RCRA, CERCLA, and Bevill will be included in the plan.

- *AMSELCO - Colosseum Gold Mine - California*

TRC prepared the emissions inventory, summary of modeling results, and full air quality permit application for AMSELCO's Colosseum Mine. Using fugitive dust emission factors specifically applicable to precious metals mines, fugitive dust emission rates from all mining activities were computed and allocated to area sources for modeling. Predicted concentrations were shown to be less than applicable TSP and PM10 standards, and a New Source Review Permit was granted to AMSELCO by San Bernardino APCD.

- *Lead-Zinc Mine and Mill - New Mexico*

TRC represented a client during investigations by and negotiations with the State of Department of the Environment. The state investigation of closed facilities was for the purpose of evaluating possible environmental impacts for possible inclusion of the site on the National Priorities List. No enforcement action resulted.

- *Steel Strip Manufacturer - Wastewater Treatment/Sludge Handling*

TRC performed wastewater treatment evaluations for a steel strip manufacturer. These studies included: 1) upgrading an oil/water separation system, 2) examining disposal options for buffing sludge, 3) designing a treatment and/or recycling system for acid and alkaline cleaning wastes, 4) developing disposal options for oil sludges, and 5) updating an oil/hazardous substances SPCC plan. The initial studies included problem definition, an evaluation of the cost-effectiveness of alternative systems, and conceptual design. Later phases involved detailed plans and specifications for new equipment and installation.

- *Steel Mill Pickle Liquor Process - RCRA Delisting Petition and Upgrading of a Treatment System*

The effluent from a pickle liquor treatment system was violating permit guidelines for solids and heavy metals. TRC upgraded the treatment system beginning with a series of jar tests to determine the optimum neutralization chemical. Later, equipment modifications were recommended to improve flocculation and sedimentation.

TRC also investigated treatment sludge dewatering and disposal and delisting the sludge as hazardous waste under Resources Conservation and Recovery Act regulations.

- *Specialty Steel Manufacturer - Site Assessment, Initial Design, and Environmental Permitting of a Slag Disposal Landfill*

For a Connecticut manufacturer of specialty alloys, TRC provided all technical services associated with obtaining necessary environmental permits for the landfill disposal of slag. The work was done in four distinct phases: preparation of a permit plan, site investigations, preparation and filing of permit applications, and follow-up liaison with regulatory personnel. The permit plan phase included meeting with all potentially-involved units of the Connecticut Department of Environmental Protection (CTDEP) to discuss the proposed project, its permit needs, and the procedure and schedule for obtaining each permit. Application formats and necessary supporting data were agreed upon at that time. A report was prepared for client use describing all applicable permits, potential problems, etc.

- *Metals Recovery Plant - Environmental Audit for Property Conveyance*

Prior to planned sale of a secondary metals recovery plant in northern California, A manufacturing firm retained TRC to review necessary environmental regulations which must be met. TRC is conducting an environmental audit to evaluate existing regulations and to identify other potential environmental liability concerns for the client. Important aspects of the audit include reviewing available data on site conditions and plant operations, inspecting the facility, and reviewing historical aerial photographs to evaluate past site conditions.

- *Determination of Arsenic Emissions from Glass Furnaces*

TRC conducted a comprehensive program to evaluate existing test methods and developed a method to determine arsenic emissions at different exhaust temperatures. Simultaneous sampling was performed at different temperatures to determine the difference in particulate/gaseous arsenic ratios and the effects of a control device at those temperatures. Data collected were used to develop a NESHAP arsenic emission standard.

- *Hazardous Emissions from a Metal Forging Operation*

TRC was retained to evaluate the hazardous emissions resulting from the die release lubricants used during the forging operation at a large integrated facility. Tests were done to compare the emissions from water-based and oil-based die release lubricants.

JAMES M. BECK, P.E.
PRINCIPAL CONSULTANT AND MINING ENGINEER

EXPERTISE

- Mine Waste Management and Remediation
- Tailings Reprocessing and Stabilization
- Mining Facility Audits and Assessments
- Remedial Alternatives Evaluation

SUMMARY OF EXPERIENCE

Mr. Beck is a registered professional mining engineer specializing in the engineering design, evaluation, and management of mining waste investigation and remediation. With over 14 years experience in all aspects of mining engineering and waste management, Mr. Beck's professional consulting career has concentrated on environmental and waste management consulting to mining clients for nearly ten years, while his previous industry affiliation has included Anaconda Minerals Co. and the associated subsidiaries ARCo Coal Co. and ARCo Australia, Ltd.

Most recently, Mr. Beck has been involved in the determination of the extent of contamination and the design and evaluation of remedial alternatives for mining properties located within the boundaries of large area-wide mining CERCLA (Superfund) sites in the western U.S. A major focus in these efforts has been the evaluation of potential remining and reprocessing methods for waste rock, tailings, and sub-grade ores in combination with employing traditional remedial measures such as diversion structures, stabilization, and cap and cover systems. Additionally, he has been responsible for evaluations of environmental liabilities and hazards related to acquisitions and divestitures associated with proposed, inactive and operating facilities, as well as technical evaluations for permit requirements, environmental assessment (EA) documents, reclamation bonding, and corrective actions related to compliance issues or violations.

As a consultant, Mr. Beck has completed a wide range of assignments on behalf of mining clients, legal counsel, and financial institutions. These include design of low-level radioactive processing residue cleanup plans and disposal cells, development of heap leach facilities for precious metals recovery, assessment of permit and compliance status for underground and open-pit facilities for most mineral commodities, economic analyses and feasibility studies related to environmental controls, acid mine drainage water treatment, and evaluation of subsidence and other hazards.

While with Anaconda Minerals Co. Mr. Beck was responsible for the evaluation and remediation of inactive precious metals properties in Anaconda's surplus properties inventory. The focus of this effort was to identify those properties with significant potential for environmental liabilities attributable to past mining or processing activity on-site, and to determine the most economically feasible method of remediating the site (usually employing a reprocessing approach) prior to its disposition for redevelopment or other subsequent use. This included identification and elimination of hazards, drilling and confirmation of recoverable reserves in tailings, sub-grade ore or waste dumps and ore stockpiles; coordination of metallurgical testing and optimization for leaching parameters; identifying, agency negotiation, and securing of all required permits; development of water supply systems and utilities to site; and development of site reclamation final contour plans.

Selected Mining Experience

- Silver City Mill Tailings and Smelter Slag, Eureka, Utah - Project manager for development of precious metals recovery operation to remediate environmental concerns associated with airborne dispersion of chloride roast tailing materials. Project involved tailings reprocessing facility design and feasibility studies, metallurgical testing, and permitting for a cyanide heap leach operation.

- Denver Radium (Superfund) Site, Denver, Colorado - Project manager for radium-contaminated soils project at a Superfund site industrial facility. Developed extensive site sampling plans for former radium production facility, risk assessments, remedial action plan, and conducted regulatory negotiation and interfacing. Design engineering of liner and cover system for low-level radioactive waste disposal cells proposed for location atop decommissioned uranium/vanadium heap leach pad.

- Cement Kiln Dust Disposal (Superfund) Sites, Salt Lake City, Utah - Provided conceptual engineering designs of several alternative remedial action methodologies for kiln dust disposal sites impacting area groundwater. Alternatives included variations on clay capping, asphaltic capping and surface stabilization/fixation. Provided economic comparisons of alternatives to methodologies developed in the site RI/FS.

- Golden Cycle Mill, Colorado Springs, Colorado - Developed and managed pre-acquisition due diligence evaluation of potential environmental liabilities associated with the Gold Hill Mesa tailings, formerly the site of the Golden Cycle Mill. Scope of investigation include surface water analyses, implementation of a groundwater monitoring network, and tailing material characterization and analyses.

- Metallurgical Processing Facility, Pahrump, Nevada - Project manager for RCRA corrective action involving regulatory negotiation, site characterization to determine extent of soil and groundwater contamination, and remedial action for abandoned process wastewater lagoons, tailing disposal areas, and slag heaps associated with mineral processing operations. Successfully negotiated cost effective site cleanup addressing heavy metals, WAD and total cyanide, and process chemical disposal concerns.

- Former Carey Salt Mine, Lyons, Kansas - Preliminary investigation of sodium chloride contamination of soils and groundwater due to salt stockpiling and brine evaporation ponds associated with underground salt mine. Also included definition of environmental liabilities associated with former use of the underground workings for experimental radioactive waste disposal operations.

- Bodie Bluff and Silver Hill Claim Groupings, Bodie California -- Conducted pre-acquisition due-diligence evaluation of potential environmental liabilities. Included tailing and dump material analyses, and evaluation of environmental concerns due to previous mining and milling practices.

- Elk Peak Project - Pre-acquisition due diligence evaluation of potential environmental liabilities associated with the Elk Peak Mine and the former U.S. Gypsum Heath Mine and plant, proposed for changeover to a cyanidation plant with underground backfill tailings disposal. Review and recommendations were provided concerning closure/reclamation aspects of Heath property prior to acquisition.

- Gilt Edge Property, Gilt Edge, Montana - Pre-acquisition evaluation of liabilities associated with claim grouping that included the former "Golden Maple" heap leach operation. The Golden Maple operation experienced an overtopping of solution ponds in 1985, resulting in a State of Montana Emergency Order requiring containment and remedial action. Recommendations resulted in exclusion of heap leach area from overall acquisition.

- Yak Tunnel/California Gulch (Superfund) Site, Leadville, Colorado - Provided technical support to litigation by potentially responsible party with respect to claim holdings located within extensive area included in NPL and state of Colorado natural resource damage assessment (NRDA) suits. Project involved characterization of mine waste rock and evaluation of contributions to heavy metal soil contamination, surface leaching of metals, and acidic groundwater concerns in the district that subsequently impact the headwaters of the Arkansas River. Also provided remedial design engineering and economic evaluations.

- Balmat Mines Division, Gouverneur, New York - Performed multi-tiered due diligence investigation of the Pierrepont mine facility, the decommissioned Edwards tailing impoundment, the inactive Balmat No.2 surface facilities and decommissioned tailings impoundment, and the Balmat No. 3 zinc mining/milling operations and tailing disposal facility. Evaluated water quality issues (groundwater and surface discharge of tailings decant water) and other aspects of environmental compliance and provided cost estimates for remedial measures.

- Darwin Mine and Heap Leach, Darwin, California - Pre-acquisition due diligence investigation of mine, mill, decommissioned heap leach, and Merrill-Crowe precious metal recovery plant. Key issues involved standby status of waste discharge permit and determination of inactive/closure status with respect to existing heap leach liner design to maintain operational readiness and compliance. Reviewed laboratory data on residual cyanide levels in heap collected during post-closure monitoring.

- El Plomo Project, San Luis, Colorado - Pre-acquisition evaluation of liabilities associated with claim grouping that included the former "OJ" heap leach operation, site of a 1976 cyanide release due to surface runoff. Release resulted in precedent-setting litigation pertaining to "Point-Source" determinations as applied to heap leach operations. Provided evaluation of permitting requirements and preliminary recommendations for tailings facility siting alternatives for proposed large-scale operation.

- Contaminated Soil Remedial Action, Cheyenne, Wyoming - Project manager for regulatory interfacing (Wyoming DEQ and EPA); characterization and definition of extent of contamination, remedial action, transport and disposal associated with benzene-toluene-xylene contaminated soils from a fire suppression training facility. Project included design and installation of groundwater monitoring network.

EDUCATION

1977 B.S. Mining Engineering, Michigan Technological University
1980 M.B.A. Graduate Studies, University of Colorado

PROFESSIONAL CERTIFICATIONS/AFFILIATIONS

Professional Engineer: Colorado (#25393) Nevada (#7938)
Michigan (#34082)[1] Utah (#8269)
Certified Hazardous Materials Manager (#1150)
Registered Environmental Assessor (California #1150)

SME-AIME, Member
Colorado Mining Association, Director
Vice Chairman, Environmental Affairs Committee
Member, Solid and Hazardous Waste Subcommittee
Northwest Mining Association, Member

PUBLICATIONS

Beck, J. M., "Mining Remedial Actions From a Technical Viewpoint: A Superfund Update", Proceedings from the 97th Annual Northwest Mining Association Convention, Spokane, Washingtin, 1991.

Beck, J.M., Engelking, J.M., and Elder, R.L., "Resource Recovery: An Economic Approach to Remediation", Published in Mining and Mineral Processing Wastes, pp 243-248, SME-AIME, 1990.

Beck, J.M., "Technical and Financial Considerations in Precious Metal Property Acquisitions", Proceedings of the 1989 Engineering and Mining Journal International Gold Expo, Reno, Nevada.

Beck, J.M., "Avoiding the Hidden Costs of Reopening Inactive Mining Properties", Proceedings of the 1989 Multinational Conference on Mine Planning and Design, Lexington, Kentucky.

Beck, J.M., "Regional Hydrogeological Implications on the Property Transfer Assessment: A Case Study", Proceedings of the 9th Symposium on Geotechnical and Geohydrological Aspects of Waste Management, 1987, Fort Collins, Colorado.

Beck, J.M., "Considerations for Alternative Low-Level Radioactive Waste Disposal Sites", Proceedings of the 8th Symposium on Geotechnical and Geohydrological Aspects of Waste Management, 1986, Fort Collins, Colorado.

JAMES R. MUHM, CPG
ENVIRONMENTAL COMPLIANCE SPECIALIST

EXPERTISE:

- Environmental Due Diligence (Phase I) Audits
- Regulatory Affairs/Community Relations

SUMMARY OF EXPERIENCE:

Mr. Muhm is a Certified Professional Geologist specializing in the environmental aspects of mining operations. While serving as Director of Government Affairs for Occidental Minerals Corporation, he developed and implemented one of the first environmental audit programs ever used in the mining industry. Mr. Muhm has conducted more than 50 environmental due-diligence investigations and Phase I environmental audits of mines, associated mills, hot mix asphalt plants and pre-mix concrete plants. His experience as a professional geologist, coupled with his background in mining, enables him to conduct an environmental investigation thoroughly and efficiently. Mr. Muhm is an active member of SME-AIME and the National Association of Environmental Professionals.

- *Topaz Mountain, Utah.* Pre-acquisition environmental due-diligence investigation of beryllium mine site, haul route to mill site, existing groundwater pollution in area of proposed mill site, and potential occupational health hazards within mill.

- *Golden Reward Mine and Mill, Lead, South Dakota.* Environmental due-diligence investigation of permitting probabilities, legislative and regulatory attitudes and expectations, protection of groundwater and surface water resources, accommodation of competing land uses, participation in adoption of acceptable county mining ordinances, and selection of environmental permitting contractor.

- *Five Aggregate Quarries Located in Minnesota, New Mexico and Washington.* Pre-acquisition evaluation of liabilities associated with properties operated by individuals who leased them from major industry owner. Investigations included permit adequacy and permit compliance, potential liability from neighboring properties, potential enforcement action, and site inspections.

- *Meridian Minerals Company Aggregate Quarries and Plants in Wyoming, Minnesota, Oklahoma, Oregon, Montana, Texas and Washington.* Environmental audits included evaluation of permit adequacy, permit compliance and liability associated with facility operations.

- *Yuba Placer, California.* Pre-acquisition environmental due-diligence evaluation of gold dredge operation, extraction circuit and gold recovery mill, and associated silica sand plant and aggregate plant leased to other operators. Major emphasis of site assessment involved liabilities of former municipal landfill and industrial wastes from dredging, and occupational health considerations.

- *Four Quarries and Two Processing Plants, British Columbia.* Environmental audits focused on permit compliance, regulatory concerns, and occupational health considerations.

- *Solano Concrete, California.* Pre-acquisition environmental due-diligence investigation of aggregate quarry, hot mix asphalt plant, and pre-mix concrete plants. Evaluated liability of surface water and groundwater pollution, protected species, existing rights-of-way, petroleum and lube management practices, and an evaluation of citizen initiatives.

- *Platoro Mine and Mill, Colorado.* Prepared environmental portion of feasibility document preparatory to bank financing. Environmental investigations of gold mine and mill included permit status, adequacy of treatment of mine drainage and suitability of candidate mill tailings sites.

- *Complex of Seven Dolomite Quarries and Processing Plant, Washington.* Environmental audits included permit adequacy, waste management, occupational health considerations and adequacy of mine planning.

- *Cities Service Copper Company, Miami, Arizona.* Environmental audit for seller. Investigation included permit adequacy and permit compliance, site assessments, and evaluation of community relations.

- *U.S. Antimony, Townsend, Montana.* A pre-acquisition environmental due-diligence investigation of an antimony mine and mill, and of Idaho gold properties and a mill. Assessment included permit adequacy and compliance, occupational health considerations, and potential legislative and regulatory constraints on future productions.

- *Ridgeway Mine and Mill, South Carolina.* Environmental due-diligence investigation of a gold mine and mill, permit compliance, regulatory attitudes, future operational constraints, environmentally related financial obligations, and an assessment of community relations.

- *Wing Hill Garnet, Rangeley, Maine.* Environmental due-diligence investigation of an industrial garnet mine and mill. Assessment included permitting requirements, haul route evaluation, suitability of the mill, and community attitudes.

- *Green Mountain, Wyoming.* Environmental due-diligence investigation of a proposed underground uranium mine, including permitting constraints, mine waste disposal, and protection of groundwater resources.

- *Meridian Minerals Proposed Quarry, Corson, South Dakota.* Participation in formulation of county mining ordinance, presentation of company plans at public hearings, and coordination of permitting effort. Community education constituted a major part of the assignment.

EDUCATION:

1950 B.S. Geology, University of Wyoming

PROFESSIONAL AFFILIATIONS:

SME-AIME
Certified Professional Geologist (#2598)
Registered Environmental Professional (#4018)

RICHARD V. BECK, P.E.
PRINCIPAL GEOTECHNICAL ENGINEER

EXPERTISE:

- Mining and Solid Waste Facilities
- Geotechnical, Hydrologic and Hydraulic Modeling
- Remedial Engineering and Project Management
- Permitting

EXPERIENCE:

Richard V. Beck is a registered professional engineer specializing in the engineering design, evaluation and project management of mining and solid waste facilities projects including heap leach, tailings dam and landfill facilities. Mr. Beck possesses over 15 years of experience as a consulting geotechnical and water resources engineer. He has provided consulting services for various geotechnical, mining, solid waste and water resources consulting firms on numerous projects.

In the mining field, Mr. Beck has been responsible for both the geotechnical and water related considerations pertaining to the design, evaluation and management of heap leach facilities, tailings dam facilities and other related mining facilities. He has been responsible for liner designs and evaluations, slope stability analysis, groundwater and seepage analysis, and pond and major impoundment designs including hydrologic, hydraulic and water-balance analysis and considerations. In addition, Mr. Beck has been responsible for implementing various geotechnical, hydrologic and hydraulic computer programs as part of his consulting experience. He has also been actively involved in the permitting aspects of various mining facilities.

In the solid waste area, Mr. Beck has been involved with the geotechnical aspects of various solid waste facilities, including geotechnical field investigations, slope stability analysis, liner and cover system evaluations and seepage, settlement and strength considerations. In addition, he has been involved with the modelling of leachate conveyance and leachate collection systems pertaining to both proposed facilities as well as remedial efforts for existing facilities not in regulatory compliance. Mr. Beck has also been responsible for surface water control analysis and evaluations for various sold waste sites including diversion channels, sediment ponds, and gravity and pumped storm water conveyance systems. He has also been involved with watershed and floodplain modeling utilizing the Army Corps of Engineers HEC1 and HEC2 computer programs. Mr. Beck has been responsible for the permitting issues of numerous solid waste facilities including conducting periodic site reviews, reports of disposal site information and updates of waste discharge requirements and siting studies, EIS's and EIR's.

<u>Heap & Dump Leaching</u>

- Ridgeway Project, Columbia, South Carolina - Responsible for geotechnical, hydrological, and hydraulic functions pertaining to the design of major heap leach facility projects, including reservoir impoundment facility for water supply to facility and resulting water balance. Involved in geotechnical aspects of liner selection and monitoring systems.

- Yellow Cat Mine Project, near Winnemucca, Nevada - Responsible for geotechnical, climatological and water related issues pertaining to a heap leach facility in northern Nevada.

- Tonkin Springs Project, Tonkin Springs, Nevada - Responsible for development of climatological, hydrological, and water balance data for large heap leach facility in central Nevada.

- Quartz Mountain Project, Quartz Mountain, Oregon - Responsible for development of climatological, hydrological, and water balance data for major heap leach facility in north central Oregon subject to major precipitation, snowfall and snowmelt events.

- Prairie Diggings Project, John Day, Oregon - Responsible for development of climatological, hydrological, and water balance data for a heap leach facility in south central Oregon subject to major precipitation events in addition to snowfall and snowmelt events.

- San Luis Project, San Luis, Colorado - Responsible for climatological, hydrological, and water related issues for a combination heap leach facility and tailings dam facility in southern Colorado.

- Lavon Project, Cripple Creek, Colorado - Responsible for preparation of groundwater quality baseline data as well as climatological, hydrological, and flood data for heap leach facility in southern Colorado.

- Zenda Mine, Tehachapi, California - Responsible for project management and permitting efforts of a proposed synthetically lined valley leach facility on steeply sloping ground. Due to the "dam-like" nature of the facility, it was necessary to permit the facility through DWR as a non-jurisdictional "dam" by providing a moveable 10,000 year spillway in addition to permitting of the leachate collection system through the CRWQCB.

Solid Waste Facilities Projects Including Liners, Cover and Leachate Collection Systems

- County of Sacramento Kiefer Road Landfill Cover Closure - Responsible for project and construction management of all aspects of final closure and cover to a portion of the County of Sacramento's only major landfill. The project included geotechnical investigation for an onsite cover material source, development of a QA/QC program and preparation of construction plans. The project included an extensive geotechnical testing program for certification of the cover closure materials and construction to the RWQCB.

- County of Sacramento Kiefer Road Landfill Expansion Project - Project Manager responsible for siting of landfill expansion location for County of Sacramento's only major landfill. Responsible for all engineering related issues pertaining to suitable site location selection.

- Durham Road Landfill Expansion Project, Freemont, California - Project geotechnical engineer on a major landfill expansion project in the San Francisco Bay Area. Responsible for investigation of potentially excessive consolidation settlements, liner suitability and the influence of upward gradient groundwater on the landfill's performance. Responsible for the development of a geotechnical testing program to assess the suitability of potential liner systems and leachate collection facilities.

- Nevada County Landfill Remediation and Expansion, Nevada County, California - Project geotechnical engineer responsible for investigation, modeling and remediation efforts for an existing leachate collection system for a landfill in non-compliance with the RWQCB. In addition, was responsible for evaluation of leachate collection, liner and cover systems for proposed landfill expansion and closure requirements. Both liners and covers evaluated, considered synthetic and earthen materials as well as composite materials.

- B & J Dropbox Landfill Permit Revisions and Updates, Solano County, California - Project geotechnical engineer responsible for evaluation of leachate collection system for a solid waste facility permit update and revision including Report of Disposal Site Information (RDSI), Report of Waste Discharge (ROWD) and the Periodic Site Review (PSR).

- City of Willits Landfill Expansion, Mendocino County, California - Project Manager responsible for developing a RWQCB approved plan and approach for expanding a moderately sized landfill in Northern California, potentially to be utilized as part of a Joint Powers Authority. The plan and approach addressed critical issues of stability, liner and cover evaluations as well as leachate collection considerations for the landfill, situated in mountainous terrain and adjacent to a major natural drainage channel.

EDUCATION:

1975	B.S.	Physics, Elmhurst College
1977	B.S.	Civil Engineering, Tri-State University
1983	M.S.	Civil Engineering (Geotechnical Engineer), University of Colorado

PROFESSIONAL CERTIFICATIONS/AFFILIATIONS:

Professional Engineer: Colorado (#23994)
California (#C47057)
NSPE, Associate Member

PUBLICATIONS:

"Performance of the Modified Cam Clay Model for Simulations of Soils Under Different Stress Paths," Fifth International Conference on Mathematical Modeling, IAMM. University of California, Berkeley, California, July 1985

"Optimization Technology of Heap Leach Pad Liner Selection," 116th Annual Meeting of AIME, SME, and TMS, Geotechnical Aspects of Heap Leach Design Symposium and Proceedings. Denver, Colorado, February, 1987

SEMINARS/WORKSHOPS:

1. EPA Seminar - Design and Construction of RCRA/CERCLA Final Covers, 1990
2. U. of Wisconsin - Seminar on Computer Applications to Geotechnical Engineering, 1986

GERALD V. JERGENSEN, II
SR. PROCESS ENGINEER

EXPERTISE:

- Process Development and Design
- Extractive Metallurgy
- Aqueous Chemistry
- Crushing and Grinding Circuit Design

EXPERIENCE:

Mr. Jergensen is a metallurgical engineer specializing in process engineering including process development and design, extractive metallurgy, aqueous chemistry, and crushing and grinding circuit design. His experience has included all major aspects of environmental control such as waste minimization and material recycling/reprocessing, flue gas desulfurization technology, hazardous and toxic materials management and technology development.

Mr. Jergensen's professional career of over 25 years has included employment with a number of major engineering and process design firms as well as process equipment manufacturers. As a consultant, Mr. Jergensen has completed numerous process development and plant design assignments on behalf of major chemical producers and mining firms throughout the world. He is active in SME-AIME, is a past chairman and director of that society's Minerals Processing Division, has authored a number of publications on comminution circuit design, mineral processing, and engineering feasibility studies, and is an adjunct professor of metallurgy at Colorado School of Mines.

- TRC Environmental Consultants, Inc. Application of metallurgical process technology to the design and implementation of environmental control strategies and operating systems. Services include feasibility studies, permit management, engineering management, and construction management.

- Minproc Engineers. Design and construction of environmental control facilities for various metallurgical processes, including secondary lead, molybdenite roasting, copper extraction, and refining. By products of recovery processes included sodium sulfate, sulfuric acid rhenium.

- Cyprus Miami Copper Company. Process audit of leaching, solvent extraction and electrowinning operations. Developed methods for reducing losses of solvents to various recycled and waste streams. Also performed audit of metal hydroxide waste recycling program in smelter operation and "due diligence".

- Phelps-Dodge Corp. Developed process concepts for combined recovery and treatment of process dusts, slags and acid plant blowdown streams. Specified process equipment for crushing, grinding and flotation of slags from an Outokumpu Flash Smelting Facility. Similar work performed for slag grinding at a Noranda Process smelter.

- Confidential Client. Examined processes, products, and by-products for a fully integrated lead-zinc-silver production facility. Developed process models for a concentrator, lead smelter and zinc roasting and electrolytic refining complex. The model was used to identify species, sources and pathways of various metals through the facilities and to support PRP assessments.

- Kerr McGee Chemical Co., Trona Production Facilities. Analysis of applications for sodium compounds in flue gas desulfurization processes.

- Confidential Client. Survey and evaluation of cyanide destruction and recovery processes. Examined processes, capital and operating costs and performance to attain or minimize cyanide content in tailings pond waters and barren solutions.

- Outokumpu, Inc., Denver, Colorado. Application and design of large capacity mineral flotation cells; design and installation of ceramic disc filter system for concentrate dewatering; design evaluation and installation of grinding mill and X-ray instrumentation and controls.

- Newmont Gold Co., Gold Quarry Mine, Carlin, Nevada. Design and construction of crushing plant modifications to increase mill capacity and modifications to flash chlorination processes to improve refractory gold recovery.

- CoBank National Bank for Cooperatives, Denver, Colorado. Evaluation of process waste streams associated with various agricultural process including bulk fertilizer manufacture, storage and distribution, cane sugar refining, cottonseed oil extraction, and food products processing and canning.

- Denver Mineral Engineers, Denver, Colorado. Metallurgical consulting for design and construction of carbon adsorption and stripping processes as related to precious metals recovery circuits. Design/construction and installation of electro-chemical process equipment and metallurgical furnaces. Various project locations throughout the U.S.

- Yukon Placer, Whitehorse, Canada. Feasibility level study of placer gold property. Evaluation of reserve estimates and wash plant design.

- Alma Placer. Alma, Colorado. Technical evaluation of reserves and metallurgical recoveries in support of tax litigation.

- Rosario Resources Corporation, El Mochito Mine, Honduras, Central America. Provided technical evaluation of process flow schematics and equipment specification for mill expansion to 2,500 tons per day at lead-zinc-silver mining operation located near San Pedro Sula.

- The World Bank, Washington, D.C. Comprehensive technical and economic review of the Bolivian minerals industry. Feasibility level studies of conceptual strategies for industry modernization.

EDUCATION:

1972	M.B.A.	Finance, University of Colorado
1965	B.S.	Minerals Engineering, Colorado School of Mines

Oregon

DEPARTMENT OF
ENVIRONMENTAL
QUALITY

March 25, 1992

David Hoppens
Civil Engineers
Box 130
1365 Highway 21 North
Malo, WA 99150-0130

Re: Proposal for Technical Advice on Mining Rules

Dear Mr. Hoppens:

Thank you for submitting a proposal in response to our "Request for Proposals for Technical Advice on Mining Rules" dated February 7, 1992.

We have evaluated the proposals received, and have made a determination to select a proposal submitted by TRC Environmental Consultants, Inc.

Thank you for taking the time to prepare and submit a proposal. If you have any questions, please feel free to contact us.

Sincerely,

Harold L. Sawyer
Inter/Intra Program Coordinator

HLS:1

811 SW Sixth Avenue
Portland, OR 97204-1390
(503) 229-5696

Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

March 25, 1992

James M. Beck, P.E.
TRC Environmental Consultants, Inc.
7002 South Revere Parkway, Suite 60
Englewood, CO 80112

Re: Proposal for Technical Advice on Mining Rules

Dear Beck:

Thank you for submitting a proposal in response to our "Request for Proposals for Technical Advice on Mining Rules" dated February 7, 1992.

We have evaluated the proposals received, and have made a determination to select your proposal. Enclosed is a draft contract for your review. Please advise me of any concerns or changes you would suggest. We will then prepare the final contract for your signature (three copies). Before you will be able to start work, we will have to forward the signed Contract to Salem for approval by the State Executive Department. We will advise you when work can begin.

If you have any questions, please contact me.

Sincerely,

Harold L. Sawyer
Inter/Intra Program Coordinator

HLS:1

Enclosure

811 SW Sixth Avenue
Portland, OR 97204-1390
(503) 229-5696

DRAFT

PERSONAL SERVICE CONTRACT

This contract is between the State of Oregon acting by and through its Department of Environmental Quality hereafter called Department, and TRC Environmental Consultants, Inc., 7002 South Revere Parkway, Suite 60, Englewood, CO 80112, hereafter called Contractor.

1. Retirement System Status

Contractor is not a contributing member of the Public Employees' Retirement System and will be responsible for any federal or state taxes applicable to this payment. Contractor will not be eligible for any benefits from these contract payments of federal Social Security, unemployment insurance, or Workers' Compensation, except as a self-employed individual.

2. Statement of Work

a. Contractor agrees to accomplish the following work under this contract:

The statement of work is contained in Exhibit A attached hereto and by this reference made a part hereof.

b. Contractor agrees to the following delivery schedule for the work mentioned in (2)(a):

Begin Work:	Upon Notification of Contract Execution
Participate in Public Meeting:	Within 15 calendar days of Contract Execution
Submit Draft Written Report to DEQ:	Within 45 calendar days of Contract Execution
Submit Final Report to DEQ:	Within 15 calendar days of Receipt of DEQ Comments on Draft Report

3. Consideration

a. Department agrees to pay Contractor not to exceed the sum of $18,450 for accomplishment of the work.

b. Interim payments shall be made to Contractor. Interim payments that are included as part of this contract shall be made according to the following schedule:

Upon Submittal and review of Draft Report and Receipt and Approval of Invoice	50%

4. Travel

Travel expenses are included in the amount of consideration listed in 3 above.

5. Government Employment Status

If this payment is to be charged against Federal Funds, the Contractor certifies that he/she is not currently employed by the Federal Government.

6. Subcontracts

Contractor shall not enter into any subcontracts for any of the work scheduled under this contract without obtaining prior written approval from the Department.

7. Dual Payment

Contractor shall not be compensated for work performed under this contract from any other Department of the State of Oregon.

8. Funds Available and Authorized

Department certifies at the time the contract is written that sufficient funds are available and authorized for expenditure to finance costs of this contract within the Department's current appropriation or limitation. Contractor understands and agrees that Department's payment of amounts under this contract attributable to work performed after June 30, 1993 is contingent on Department receiving from the Oregon Legislative Assembly sufficient appropriations, limitations under this contract. In the event the Oregon Legislative Assembly fails to approve sufficient appropriations, limitations or other expenditure authority, Department may terminate this contract, effective upon the delivery of written notice to Contractor, with no further liability to Contractor.

9. Amendments

The terms of this agreement shall not be waived, altered, modified, supplemented or amended, in any manner whatsoever, except by written instrument signed by the parties.

10. Termination

This contract may be terminated by mutual consent of both parties, or by either party upon 30 days notice, in writing and delivered by certified mail or in person.

The Department may terminate this contract effective upon delivery of written notice to the Contractor, or at such later date as may be established by the Department, under any of the following conditions:

a. If Department funding from federal, state, or other sources is not obtained and continued at levels sufficient to allow for purchase of the indicated quantity of services. The contract may be modified to accommodate a reduction in funds.

b. If federal or state laws, rules, regulations or guidelines are modified, changed, or interpreted in such a way that the services are no longer allowable or appropriate for purchase under this contract or are no longer eligible for the funding proposed for payments authorized by this contract.

c. If any license or certificate required by law or regulation to be held by the Contractor to provide the services required by this contract is for any reason denied, revoked, or not renewed.

Any such termination of this contract shall be without prejudice to any obligations or liabilities of either party already accrued prior to such termination.

The Department by written notice of default (including breach of contract) to the Contractor may terminate the whole or any part of this agreement:

a. If the Contractor fails to provide services called for by this contract within the time specified herein or any extension thereof; or

b. If the Contractor fails to perform any of the other provisions of this contract, or so fails to pursue the work as to endanger performance of this contract in accordance with its terms, and after receipt of written notice from the Department, fails to correct such failures within 10 days or such longer period as the Department may authorize.

The rights and remedies of the Department provided in the above clause related to defaults (including breach of contract) by the Contractor shall not be exclusive and are in addition to any other rights and remedies provided by law or under this contract.

11. Captions

The captions or headings in this agreement are for convenience only and in no way define, limit or describe the scope or intent of any provisions of this agreement.

12. Access to Records

The Department, the Secretary of State's Office of the State of Oregon, the Federal Government, and their duly authorized representatives shall have access to the books, documents, papers, and records of the Contractor which are directly pertinent to the specific contract for the purpose of making audit, examination, excerpts, and transcripts.

13. Insurance

Exhibit "B" is hereby referenced and made a part of this contract.

14. State Tort Claims Act

Contractor is not an officer, employee, or agent of the State as those terms are used in ORS 30.265.

15. Execution and Counterparts

This agreement may be executed in several counterparts, each of which shall be an original, all of which shall constitute but one and the same instrument.

16. Compliance with Applicable Law

Contractor shall comply with all federal, state, and local laws and ordinances applicable to the work under this contract, including those on Exhibit B which is attached hereto and by this reference made a part hereof. Contractor agrees that the provisions of ORS 279.312, 279.314, 279.316, 279.320 and 279.733 shall apply to and govern the performance of this contract. Contractor shall certify compliance with ORS 670.600, as set forth on Exhibit C which is attached hereto and by this reference made a part hereof (not applicable to Corporations).

17. Indemnity

Contractor shall defend, save, and hold harmless the State of Oregon and the Department, its officers, agents, employes, from all claims, suits, or actions of whatsoever nature resulting from or arising out of the activities of the Contractor or his/her subcontractors, agents, or employes under this agreement.

18. Use of Recycled Paper

Contractor agrees to use recycled paper for all reports which are prepared as a part of this agreement. This requirement applies even when the cost of recycled paper is higher than that of virgin paper.

19. Ownership of Work Product

All work products of the Contractor which result from this contract are the exclusive property of the Department.

20. Nondiscrimination

Contractor agrees to comply with all applicable requirements of federal and state civil rights and rehabilitation statutes, rules, and regulations.

21. Assignment

Contractor shall not assign or transfer his/her interest in this agreement without the express written consent of the State.

22. Successors in Interest

The provisions of this agreement shall be binding upon and shall insure to the benefit of the parties hereto, and their respective successors and assigns.

23. Attorney Fees

In the event a lawsuit of any kind is instituted on behalf of the State to collect any payment due under this contract or to obtain performance of any kind under this contract, Contractor agrees to pay such additional sums as the court may adjudge for reasonable attorney fees and to pay all costs and disbursements incurred therein.

24. Force Majeure

Contractor shall not be held responsible for delay or default caused by fire, riot, acts of God and war which is beyond Contractor's reasonable control. Contractor shall, however, make all reasonable efforts to remove or eliminate such a cause of delay or default and shall, upon the cessation of the cause, diligently pursue performance of its obligations under the contract.

25. Severability

The parties agree that if any term or provision of this contract is declared by a court of competent jurisdiction to be illegal or in conflict with any law the validity of the remaining terms and provisions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if the contract did not contain the particular term or provision held to be invalid.

26. Waiver

The failure of the State to enforce any provision of this contract shall not constitute a waiver by the State of that or any other provision.

27. Executive Department Approval

Executive Department approval is required before any work may begin under this contract.

28. Merger Clause

THIS AGREEMENT CONSTITUTES THE ENTIRE AGREEMENT BETWEEN THE PARTIES. NO WAIVER, CONSENT, MODIFICATION OR CHANGE OF TERMS OF THIS AGREEMENT SHALL BIND EITHER PARTY UNLESS IN WRITING AND SIGNED BY BOTH PARTIES. SUCH WAIVER, CONSENT, MODIFICATION OR CHANGE, IF MADE, SHALL BE EFFECTIVE ONLY IN THE SPECIFIC INSTANCE AND FOR THE SPECIFIC PURPOSE GIVEN. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, OR REPRESENTATIONS, ORAL OR WRITTEN, NOT SPECIFIED HEREIN REGARDING THIS AGREEMENT. CONTRACTOR, BY THE SIGNATURE BELOW OF ITS AUTHORIZED REPRESENTATIVE, HEREBY ACKNOWLEDGES THAT HE/SHE HAS READ THIS AGREEMENT, UNDERSTANDS IT AND AGREES TO BE BOUND BY ITS TERMS AND CONDITIONS.

29. Department Data

Department of Environmental Quality
811 S.W. Sixth Avenue
Portland, OR 97204-1390

Project Officer: Harold L. Sawyer
Phone: (503) 229-5776

30. Contractor Data, Certification and Signature

TRC Environmental Consultants, Inc.
7002 South Revere Parkway, Suite 60
Englewood, CO 80112

Project Manager: James M. Beck, P.E.
Phone: (303) 792-5555

Social Security # ____________________

Federal Tax ID # ____________________

State Tax ID # ____________________

I, the undersigned, agree to perform work outlined in this contract in accordance to the terms and conditions and the statement of work made part of this contract by reference; hereby certify under penalty of perjury that I/my business am not/is not in violation of any Oregon tax laws; and hereby certify I am an independent contractor as defined in ORS 670.600.

Approved by the Contractor:

____

Signature/Title Date

31. Department and Other Signatures

Approved by the Department:

By: ______________________________________

Division Administrator Date

By: ______________________________________

(Director or Delegate) Date

Approved by the Executive Department:

By: ______________________________________

Program Manager Date

Exhibit A - Statement of Work

A. Preface

The Environmental Quality Commission (Commission) is considering adoption of rules to require mining operations using cyanide or other toxic chemicals to protect soils, groundwater, surface waters, and wildlife from contamination or harm by process solutions and waste waters. The protective measures required by the proposed rules include cyanide recovery and re-use, chemical detoxification of cyanide residues, and extensive lining and engineered closure of waste disposal facilities.

During the public participation process on the proposed rules, mining companies and associations have argued that some of the requirements are unnecessarily stringent or are unproven or are unavailable. Environmental protection organizations have argued that the proposed rules may not be adequately protective in certain respects.

The Commission has studied the proposed rules and the public comments received, and has extensively debated the policy issues associated with the rule proposal. Prior to final action to adopt proposed rules, the Commission has elected to seek an evaluation and advice on specific technical questions from an independent, knowledgeable contractor.

The entire record of the rulemaking proceeding is available for inspection as background material. The record can be reviewed in the headquarters office of the Department of Environmental Quality (DEQ or Department or Agency).

B. Scope of Work

Three policies have been established by the Commission. Contractor shall evaluate and address specific technical questions surrounding these policies. The Commission is not asking for alternative policy recommendations or evaluation of economic issues. Contractor's task is to answer the questions posed in the following paragraphs based on Contractor's knowledge, expertise, experience, review of current published technical data, and technical evaluation of the issues.

1. Questions on Liners, Leak Detection, and Leak Collection Systems

    a. Statement of Policy:

    The Commission establishes as policy that a liner, leak detection and leak collection system are necessary to assure that any leak will be detected before toxic materials escape from the liner system and are released to the environment. These systems must assure that if a leak is found, sufficient time is available to allow for the repair of the leak and clean up of any leaked material before there is a release to the environment. Natural conditions, such as depth to groundwater or net rainfall, shall be considered as additional protection but not in lieu of the protection required by the required engineered protection.

NOTE: Definition of "environment" or use of defining qualifiers is central to the issue. The Commission considers that the environment begins at the bottom of the last liner.

b. Issue:

In the proposed rule contained in 340-43-065(4), the requirements for heap leach pad liners are as follows:

(4) The heap leach pad liner system shall be of triple liner construction with between liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible membrane middle and top liners of suitable synthetic material separated by a minimum of 12 inches of permeable material (minimum permeability of 10^{-2} cm/sec);

(c) A leak detection system between the synthetic liners capable of detecting leakage of 400 gallons/day acre within ten weeks of leak initiation.

As opposed to this liner system, the Oregon Mining Council has proposed a liner characterized either as a composite liner or as a double liner and generally described as follows:

Composite Liner -- a composite liner system construction with between liner leak detection consisting of:

- An engineered, stable, low-permeability soil/clay bottom liner (maximum coefficient of permeaability of 10^{-7} cm/sec) with a minimum thickness of 12 inches;

- Continuous flexible membrane top liner of suitable synthetic material;

- A geotextile layer between the liner materials for leak detection. The leak detection and recovery system would also include collector pipes tied to the geotextile, spaced at appropriate intervals to achieve the 10-week leak initiation detection performance standard.

c. Question:

Will either or both liner systems meet the stated policy objective of the Commission?

d. Method to Answer or Address Question:

(1) Are each of the various liner systems proposed technically feasible?

(2) Will each of the various liner systems meet the stated Commission policy?

(3) For those liner systems which will meet the stated Commission policy, what level of certainty for achieving this policy do you assign to each system?

(4) Are there other liner systems which will achieve this policy and what level of certainty for achieving this policy do you assign to each?

The consultant is also asked to provide a simple comparison of typical costs for installation of the various liner configurations.

2. Questions on Tailings Treatment to Reduce the Potential for Release of Toxics

a. Statement of Policy:

The Commission establishes as policy that the toxicity and potential for long-term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment.

b. Issue:

The proposed rules in 340-43-070(1) state the following:

(1) Mill tailings shall be treated by cyanide removal and re-use prior to disposal to reduce the amount of cyanide introduced into the tailings pond. Chemical oxidation or other means shall be additionally used, if necessary, prior to disposal to reduce the WAD cyanide level in the liquid fraction of the tailings. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak-acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm.

The rules do not require removal of potentially toxic metals from tailings prior to placement in the tailings pond. The rules do require steps to control acid formation in the tailings pond and require covering upon closure with a composite cover designed to prevent water and air infiltration.

c. Question:

Do the requirements for **removal** and **reuse** of cyanide materially reduce toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

d. Method to Answer or Address Question:

(1) Are **removal** and **reuse** technically feasible?

Potential factors for consideration include:

- Is the process technically defined and understood?
- Has the process been demonstrated in practical application, and if so, where?
- Are engineering firms available to design and oversee construction?
- Are materials and equipment available to construct?

(2) Do **removal** and **reuse** (evaluated separately) materially reduce the toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

(3) What is the level of certainty you give to the answers provided above?

(4) Are there other tailings treatment technologies which will equally, or more effectively achieve the policy of the Commission?

3. Questions on Closure of the Heap Leach and Tailings Facilities

a. Statement of Policy:

The Commission establishes as policy that the closure of the heap leach and tailings disposal facilities will prevent release to the environment of toxic chemicals contained in the facility.

b. Issue:

Rule 340-43-080(4)(a), as proposed, requires that the heap shall be "... detoxified over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The WAD cyanide concentration in the rinsate shall be no greater than 0.2 ppm."

In 340-43-080(4)(b), the proposed rules require that the closure of the heap shall be "... by covering the heap with a cover designed to prevent water and air infiltration."

In 340-43-080(5), the proposed rules state that "The tailings disposal facility shall be closed by covering with a composite cover designed to prevent water and air infiltration and be environmentally stable for an indefinite period of time."

c. Question:

Do the requirements of detoxification (cyanide removal by rinsing) of the heap and covering of the heap and tailings facility to exclude air and water materially reduce the likelihood of any release to the environment of toxic chemicals and metals contained in the heap over the long term?

d. Method to Answer or Address Question:

(1) Are detoxification and covering (as prescribed in this rule) technically feasible?

(2) Do detoxification and covering (evaluated separately and together) materially reduce the likelihood of a release of toxic chemicals and metals to the environment?

(3) What is the level of certainty you give to the answers provided above?

(4) Are there other technologies which can equally or more effectively achieve the policy of the Commission?

4. Public Meeting

In addition to answering the above questions, Contractor will participate in a meeting with persons who have expressed an interest in the rulemaking proceeding by presenting testimony at public hearings. The purpose of this meeting will be to:

- Inform the interested public on the contractors approach and schedule for addressing the questions posed.

- Identifying any anticipated need to contact persons who presented testimony in the proceeding for additional information to assist in addressing the questions posed. The Commission expects an open process where all interested parties will have the opportunity to attend the meeting.

This meeting will be scheduled at a time and place mutually agreeable to DEQ and the selected contractor. DEQ will arrange the meeting and provide notice to interested parties.

5. Written Report

A written report shall be submitted as the final product of this contract. The report shall state the question being answered, summarize the methodologies for evaluating and responding to the question, and clearly state the results of the evaluation and answer given.

A draft report shall be submitted to the Department for review. The Department will provide written comments to the contractor. Contractor will then complete the report and file a single master copy, ready for reproduction, with the Department. The report shall become the property of the Department. The Department may copy and distribute the report as it deems appropriate.

D. Managing Conflict of Interest

Contractor shall disclose any potential conflicts of interest. A potential conflict of interest includes, but is not limited to, any involvement during the past five years with mining companies, mining industry groups, or environmental groups active in working on mining regulations and permitting or holding any interest in property in Oregon that may have mineral development potential. Contractor shall maintain an arm's length relationship with all parties who are or could be interested in the rule making procedure before the Commission. Contractor shall make a written record of all contacts, either to or by them, during the proposal process and the life of the contract, and shall provide a copy of the written record to the Department when the final report is presented.

EXHIBIT B
(NON-PERS MEMBER)
PERSONAL/PROFESSIONAL SERVICE CONTRACT

COMPLIANCE WITH APPLICABLE LAW

279.312 Conditions of public contracts concerning payment of laborers and materialmen, contributions to Industrial Accident Fund, liens and withholding taxes. Every public contract shall contain a condition that the contractor shall:

(1) Make payment promptly, as due, to all persons supplying to such contractor labor or material for the prosecution of the work provided for in such contract.

(2) Pay all contributions or amounts due the Industrial Accident Fund from such contractor or subcontractor incurred in the performance of the contract.

(3) Not permit any lien or claim to be filed or prosecuted against the state, county, school district, municipality, municipal corporation or subdivision thereof, on account of any labor or material furnished.

(4) Pay to the Department of Revenue all sums withheld from employees pursuant to ORS 316.167.

279.314 Condition concerning payment of claims by public officers. (1) Every public contract shall also contain a clause or condition that, if the contractor fails, neglects or refuses to make prompt payment of any claim for labor or services furnished to the contractor or a subcontractor by any person in connection with the public contract as such claim becomes due, the proper officer or officers representing the state, county, school district, municipality, municipal, corporation or subdivision thereof, as the case may be, may pay such claim to the person furnishing the labor or services and charge the amount of the payment against funds due or to become due the contractor by reason of such contract.

(2) The payment of a claim in the manner authorized in this section shall not relieve the contractor or the contractor's surety from obligation with respect to any unpaid claims.

279.316 Condition concerning hours of labor. (1) Every public contract shall also contain a condition that no person shall be employed for more than eight hours in any one day, or 40 hours in any one week, except in cases of necessity, emergency, or where the public policy absolutely requires it, and in such cases, except in cases of contracts for personal services as defined in ORS 279.061, the laborer shall be paid at least time and a half pay for all overtime in excess of eight hours a day and for work performed on Saturday or on any legal holiday specified in ORS 279.334.

279.320 Condition concerning payment for medical care and providing workers' compensation. (1) Every public contract shall also contain a condition that the contractor shall promptly, as due, make payment to any person, copartnership, association or corporation, furnishing medical, surgical and hospital care or other needed care and attention, incident to sickness or injury, to the employees of such contractor, of all sums which the contractor agrees to pay for such services and all moneys and sums which the contractor collected or deducted from the wages of employees pursuant to any law, contract or agreement for the purpose of providing or paying for such service.

2) Every public contract also shall contain a clause or condition that all employers working under the contract are subject employers that will comply with ORS 656.017.

RECYCLING

As required by ORS 279.733, in the performance of this contract the contractor shall use, to the maximum extent economically feasible, recycled paper.

INSURANCE

During the term of this contract, Contractor shall maintain in force at its own expense, insurance as noted on the **following page:**

INSURANCE CONTINUED

During the term of this contract Contractor shall maintain in force at its own expense, each insurance noted below:

1. Workers' Compensation insurance in compliance with ORS 656.017, which requires subject employers to provide Oregon workers' compensation coverage for all their subject workers (contractors with one or more employees, and as defined by ORS 656.027);

2. ☐ Required by Department ☒ Not Required by Department.
General Liability insurance with a combined single limit of not less than $1,000,000 each occurrence for Bodily Injury and Property Damage. It shall include contractual liability coverage for the indemnity provided under this contract, and shall provide that the State of Oregon, the Department of Environmental Quality and their divisions, officers and employees are Additional Insured by only with respect to the Contractor's services to be provided under this Contract;

3. ☐ Required by Department ☒ Not Required by Department.
Automobile Liability insurance with a combined single limit of not less than $1,000,000 each occurrence for Bodily Injury and Property Damage, including coverage for owned, hired or non-owned vehicles, as applicable;

4. ☐ Required by Department ☒ Not Required by Department.
Professional liability insurance with a combined single limit of not less than $1,000,000 each claim, incident or occurrence. This is to cover damages caused by error, omission or negligent acts related to the professional services to be provided under this contract. Any deductible shall not exceed $25,000 each claim, incident or occurrence.

5. Notice of cancellation or change. There shall be no cancellation, material change, reduction or limits or intent not to renew the insurance coverage(s) without 30 days written notice from the Contractor or its insurer(s) to the Department of Environmental Quality.

6. Certificates of insurance. As evidence of the insurance coverages required by this contract, the Contractor shall furnish acceptable insurance certificates to the Department of Environmental Quality prior to its issuance of a Notice to Proceed. The certificate will specify all of the parties who are Additional Insured. Insuring companies or entities are subject to State acceptance. If requested, complete policy copies shall be provided to the State. The Contractor shall be financially responsible for all pertinent deductibles, self-insured retentions and/or self-insurance.

EXHIBIT C
INDEPENDENT CONTRACTOR CERTIFICATION STATEMENT *

State agency certifies the contracted work meets the following standards:

1. Contractor will provide labor and services free from direction and control, subject only to the accomplishment of specified results.
2. Contractor is responsible for obtaining all assumed business registrations or professional occupation licenses required by state or local law.
3. Contractor will furnish the tools or equipment necessary to do the work.
4. Contractor has the authority to hire and fire employees to perform the work.
5. Contractor will be paid on completion of the project or on the basis of a periodic retainer.

____________________________ ____________________
Agency Signature Date

Independent contractor certifies he/she meets the following standards as required by ORS chapters 316, 656, 657 and 670:

1. You filed federal and state income tax returns for the business for the previous year, if you performed labor or services as an independent contractor in the previous year.
2. You represent to the public that you are an independently established business by meeting <u>four</u> (4) or more of the following:

_____ A. You work primarily at a location separate from your residence, or work primarily in a specific portion of the residence, which portion is set aside as the location of the business.

_____ B. You have purchased commercial advertising, business cards, or have a trade association membership.

_____ C. You use a telephone listing and service separate from your personal residence listing and service.

_____ D. You perform labor or services only pursuant to written contracts.

_____ E. You perform labor or services for two or more different persons within a period of one year.

_____ F. You assume financial responsibility for defective workmanship or for service not provided as evidenced by the ownership of performance bond, warranties, errors and omission insurance or liability insurance relating to the labor or services to be provided.

Contractor
Signature ____________________________ Date ______________

Entity ______________________________

***Corporations are not required to complete this form.**

TRC

TRC Environmental Consultants, Inc.

PROPOSAL TO PROVIDE TECHNICAL ADVICE ON MINING RULES

PREPARED FOR:

State of Oregon
Department of Environmental Quality

PREPARED BY:

TRC Environmental Consultants, Inc.

PROPOSAL NO: 11958-Q82-9202

March 9, 1992

TRC

TRC Environmental Consultants, Inc.

7002 South Revere Parkway, Suite 60
Englewood, CO 80112

(303) 792-5555

A TRC Company

D:\HAZ\11958PRO.069

TRC

TRC Environmental Consultants, Inc. 7002 South Revere Parkway Suite 60, Englewood, CO 80112 (303) 792-5555
Fax: (303) 792-0122

11958-Q82-9202 March 9, 1992

State of Oregon
Department of Environmental Quality
Attention: Mr. Harold L. Sawyer (6th Floor)
811 SW Sixth Avenue
Portland, Oregon 97204

RE: Proposal to Provide Technical Advice on Mining Rules

Dear Mr. Sawyer:

TRC Environmental Consultants, Inc. (TRC) is pleased to provide seven (7) copies of the enclosed Proposal to Provide Technical Advice on Mining Rules in response to your Department's February 7, 1992 Request for Proposal.

We feel that TRC is uniquely qualified to provide these services due to the combination of a number of factors, including the fact that TRC's proposed project team collectively possesses almost 100 years of professional experience in addressing the technical and regulatory issues facing proposed and active mining projects of varying magnitude; TRC has been successful in historically provided technical services in a professional manner to the regulatory community and industry clients alike; and TRC has assembled a project team that incorporates proven technical experts with a key team member, as Regulatory Affairs Liaison, that has recently been a major player in the development of similar mining rule programs in Minnesota and Maine. It is our opinion that, for this regulatory program to be a success, it will be necessary to incorporate, to the extent feasible, appropriate concerns reflecting the interests of all interested parties. To this end, we feel that it is important to establish credibility from the outset; therefore, we anticipate that TRC's Regulatory Liaison can skillfully define what aspects of the proposed technical approach incorporated in the proposal will be altered to reflect specific concerns to be identified by interested parties at the Initiation Meeting.

TRC appreciates the your consideration and the potential for the opportunity to provides these services. If you have any questions regarding the technical content or costing contained in this proposal, please do not hesitate to contact me directly at (303)792-5555.

Sincerely,

TRC ENVIRONMENTAL CONSULTANTS, INC.

James M. Beck

James M. Beck, P.E.
Manager, Hazardous Waste Investigation and Engineering

JMB:bb

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Section 1

1.0 DESCRIPTION OF THE PROJECT TEAM

1.1 Introduction to TRC Environmental Consultants, Inc.

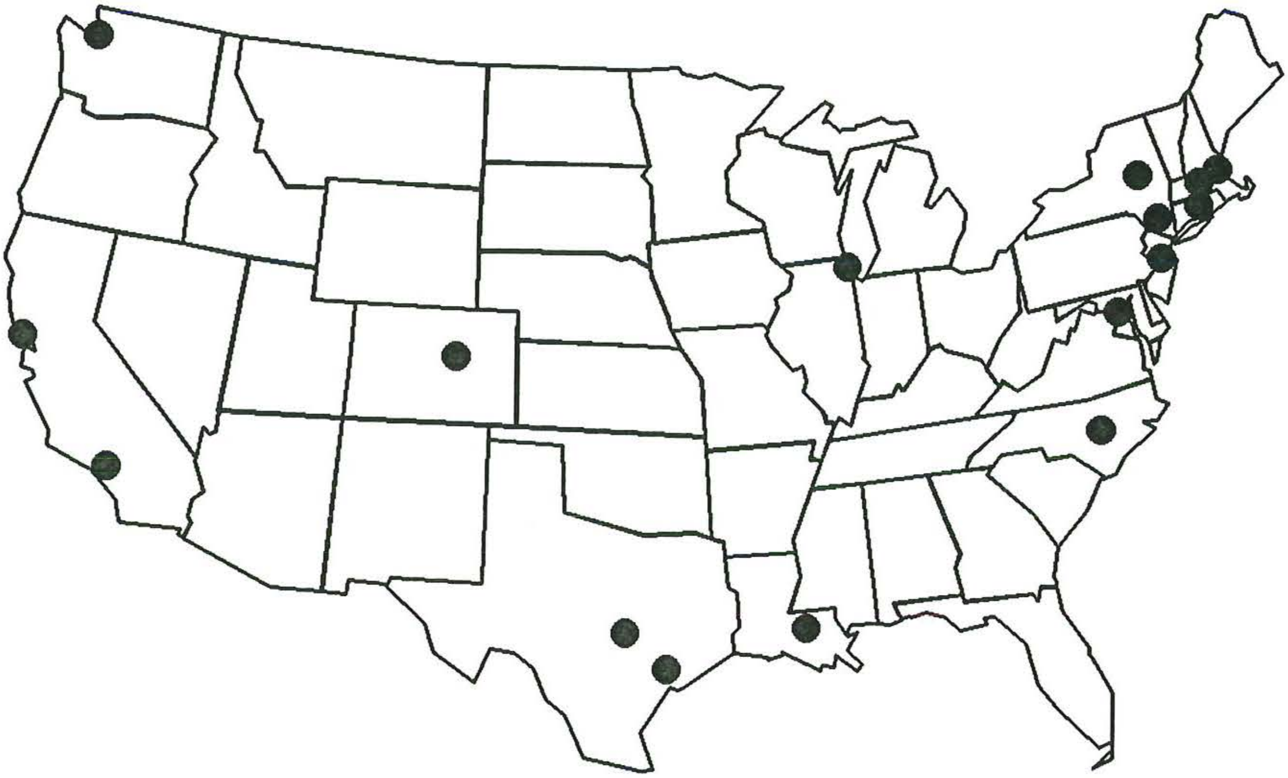
TRC Environmental Consultants, Inc. was founded in the early 1950's as an affiliate of the Travelers Insurance Company. Dedicated to environmental research and development, TRC Environmental Consultants, Inc. became an independent company in 1970 and has emerged as one of the nation's leading environmental consulting and engineering firms. Today, TRC Environmental Consultants, Inc. is a subsidiary of TRC Companies, Inc., a publicly-held corporation listed on the New York Stock Exchange. Additional subsidiaries providing environmental technologies and services include Alliance Technologies Corporation and MIE, Inc. With a combined strength of over 550 environmental professionals in 16 offices located throughout the nation, the TRC companies provide a diverse governmental, municipal, and industrial client base with a full range of environmental consulting, engineering, and technology development services. TRC Companies, Inc. assists clients in identification and solution of complex environmental problems and in establishing and maintaining compliance within the constantly evolving regulatory framework. For over 30 years, the name TRC has been synonymous with "quality"; our primary goal is to provide our clients with practical and economic solutions to protect their business interests while contributing to enhanced environmental quality and public health and safety.

TRC Environmental Consultants, Inc. (TRC) provides governmental, municipal and private sector clients with state-of-the-art science, engineering, and regulatory consulting services in the areas of hazardous waste management, site investigation, remedial engineering, site clean-up, design of treatment and disposal facilities, air pollution control, toxic substance control, environmental health, and risk management/analysis. TRC has established a long-standing reputation for providing quality environmental consulting and engineering services including the development and application of hazardous waste technologies for CERCLA (Superfund) and RCRA sites, particularly in the areas of hazardous waste minimization and treatment technologies. TRC is recognized nationally for its expertise in technology assessment, pollution prevention, and the environmental licensing and permitting of incinerators. TRC is also an international leader in air pollution measurement technology, with instrumentation capable of instantaneously measuring particulates and fibers in the workplace for both worker health protection and cost efficient ventilation operation in a multitude of applications.

Recent uses have included monitoring of: asbestos removal operations; coal mine and foundry dust suppression; ventilation/exhaust fan efficiency; measurement of airborne particulate dispersal at hazardous waste sites during remedial efforts; and aboard the Space Shuttle to monitor in-flight cabin cleanliness.

Our national staff of over 600 environmental professionals includes disciplines such as civil, mining and geotechnical engineering; metallurgical, process and chemical engineering; geology; hydrogeology; meteorology; chemistry; environmental health; air pollution control engineering; wastewater engineering; economics; and data processing. TRC's nationwide network of sixteen offices (see Figure) provides locations in Austin, Texas; Baton Rouge, Louisiana; Chapel Hill, North Carolina; Chicago (Naperville), Illinois; Denver (Englewood), Colorado; Houston, Texas; Los Angeles (Mission Viejo), California; Lowell, Massachusetts; New York, New York; Reston, Virginia; San Francisco (Petaluma), California; Seattle (Mountlake Terrace); Somerset, New Jersey; Troy, New York; Washington; and Windsor, Connecticut (Corporate Headquarters). TRC's gross revenues in 1991 were approximately $47 million, up from $42 million in 1990.

TRC COMPANIES , INC.



NATIONWIDE OFFICES

Windsor, CT
(Corporate Office)
(203) 289-8631

Seattle, WA (206) 778-5003	Denver, CO (303) 792-5555	Troy, NY (518) 283-8722
San Francisco, CA (707) 769-5250	Austin, TX (512) 328-2410	Somerset, NJ (201) 563-1100
Los Angeles, CA (714) 581-6860	Chapel Hill, NC (919) 968-9900	Bedford, MA (617) 275-5414
Lowell, MA (508) 970-5600	Chicago, IL (708) 505-8822	Baton Rouge, LA (504) 992-7761
New York, NY (212) 349-4616	Houston, TX (713) 371-3300	Reston, VA (703) 318-7757

TRC

TRC Services in the Mining and Minerals Processing Sector

TRC's multi-disciplinary staff of engineers and scientists offers a diverse and comprehensive range of environmental services to meet the particular needs of Mining and Minerals Processing clients. The Denver office of TRC is divided into divisions, headed by senior personnel with extensive mining experience, providing primary services in the following areas:

- *Remedial Engineering/Tailings and Waste Management*
- *Process Engineering and Wastewater Treatment*
- *Site Investigation*
- *Risk Management*

A brief description of the services provided by each division is described below. More detailed statements of qualification are available for each division.

1.1.1 Remedial Engineering/Tailings and Waste Management

TRC engineers have special expertise in both remediation of contamination problems and design of new treatment and disposal facilities. With direct experience working in and with the mining industry, they understand the importance of developing practical and economic solutions that are compatible with site or plant operations, while still achieving environmental control objectives.

Remedial engineering projects include CERCLA technical support, remining and reprocessing of mine wastes and tailings, stabilization and reclamation of tailings impoundments, control of seepage and groundwater contamination from tailings ponds, heap leach operations, slag piles, and waste rock dumps; repairs to leaking liners and impoundments; design of caps and other systems to prevent leaching of wastes; treatment and disposal of secondary recovery wastes; control of surface water contamination; and clean-up of contaminated soils. New facilities design includes: development of remining and reprocessing operations, tailings impoundments, heap leach facilities, slag piles and monofills, waste rock dumps, wastewater treatment lagoons, sedimentation ponds, and surface water diversions and control structures.

Groundwater contamination controls designed and implemented by TRC engineers include tailings stabilization and cover systems, geomembrane, compacted clay, and admix liners, geomembrane and soil caps for waste piles, groundwater recovery wells and interceptor drains, slurry walls and groundwater diversions, groundwater treatment systems, and injection wells.

TRC specializes in the fatal flaw analysis of environmental concerns at mining and mineral processing facilities. TRC staff can clearly identify these concerns and provide the unique and specialized perspective necessary for the engineering of solutions to problems while minimizing impacts and disruptions to ongoing or proposed operations.

1.1.2 Process Engineering and Wastewater Treatment

The solution to the high costs and potential environmental problems related to mining and process discharges is often an improved wastewater treatment system. TRC wastewater, process, and chemical engineers evaluate existing treatment plants and look for ways to optimize the system, reduce waste volumes, and better control effluent concentrations. In many cases, a single site visit and review of monitoring data can result in recommendations that help meet treatment standards and lower costs. If necessary, bench tests and pilot tests can be designed and run by TRC or the client to select optimum additives and processes. TRC engineers have extensive experience with multi-media evaluation and treatment of metals, cyanides (including process cyanide detoxification), organic and solvent wastes, acids, sludges, and leachates.

TRC's Denver office has been involved in development of innovative technologies for treatment of mine waste rock and tailings through processes resulting in metal recovery accompanied by a reduction in toxicity characteristics. Additionally, TRC recently reviewed innovative treatment technologies in foreign countries as part of an EPA Superfund research program, and has written five technical resource documents on hazardous waste treatment for application at Superfund sites.

1.1.3 Site Investigation

TRC has performed hundreds of investigations at commercial and minerals processing sites across the country, ranging from multi-year investigations at major CERCLA (Superfund) sites to one day investigations for routine environmental assessments. Depending on project needs, TRC can sample and take field measurements of groundwater and surface water, waste rock acid generating potential, sediments, soils, vegetation, ambient air, stack emissions, soil gas, asbestos, PCB's, and RCRA waste materials associated with routine mine operations.

TRC professionals work with clients to identify needs and limit investigation costs. At active mines, whenever possible, environmental investigations are coordinated with exploratory work to reduce the number of drill holes and cores. Air photos and geophysical techniques are used to cover large areas efficiently and rapidly. Sound geologic interpretation of formations and understanding of mine workings further limit the need for and costs of expensive drilling operations.

TRC personnel have the training, experience, and equipment to deal with a wide range of substances, including heavy metals, cyanide, radioactive materials, chlorinated solvents, creosote, petroleum hydrocarbons, pesticides, nutrients, pathogens, and a variety of other organic and inorganic compounds. Data evaluation tools include two and three-dimensional groundwater flow computer models; geochemical speciation models; and a variety of programs for aquifer analyses.

1.1.4 Risk Management

The objectives of environmental risk management include minimizing the risk of incidents causing environmental impact and liability, ensuring compliance with environmental regulations, and cost-effective management of wastes and environmental programs. TRC provides a wide range of services to meet these goals, including:

- regulatory analysis
- environmental compliance audits
- environmental property conveyance assessments
- risk assessment and health impact studies
- underground storage tank management programs
- emergency response planning and evaluation

1.2 Proposed Project Management and Technical Expert Team

TRC has assembled a team of regulatory development and technical experts to evaluate the DEQ's proposed mining rules. These specialists bring extensive experience specific to the technical concerns identified in the Oregon DEQ mining rule development process. TRC's proposed project organization is shown on Figure 1. Brief descriptions of project personnel and individual project roles are provided, following.

PROJECT MANAGER: James M. Beck, P.E.

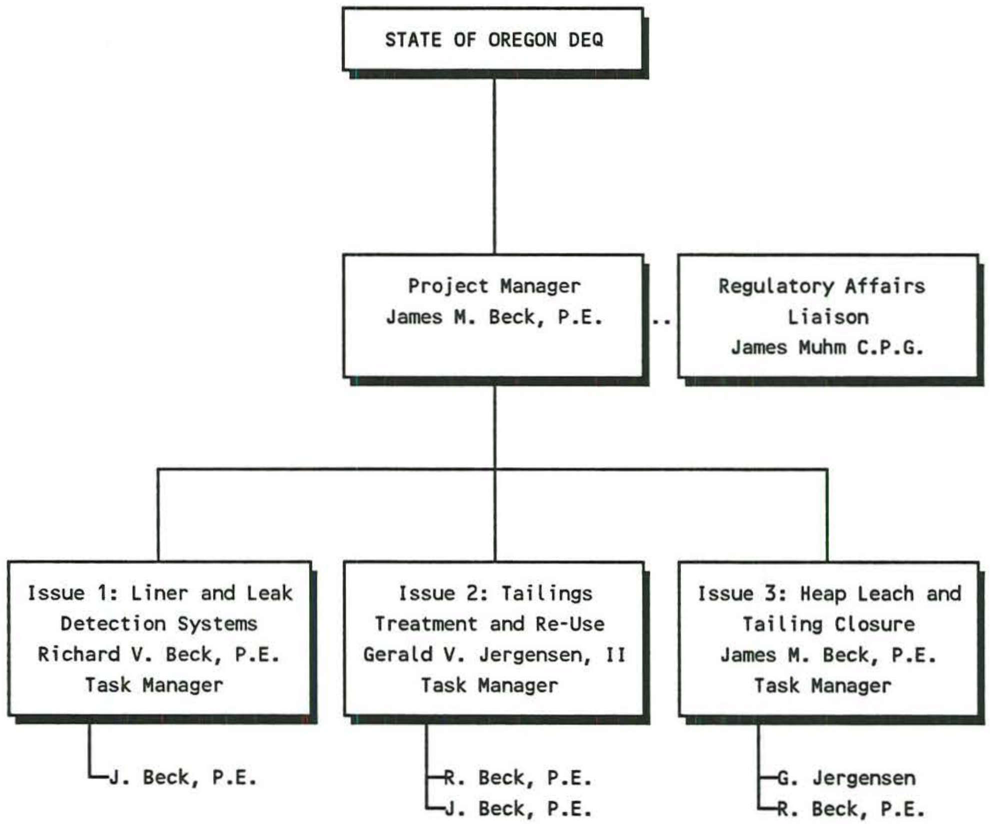
Mr. Beck will serve as project manager, and will be responsible for providing overall direction related to project technical issues, in addition to responsibilities for maintaining project budget and schedule objectives. As project manager, he will have the authority to commit TRC resources to meet those objectives, and will be the designated contact for this project.

Mr. Beck is a Registered Professional Engineer with fifteen years experience in mining and environmental engineering. He holds a B.S. degree in Mining Engineering from the Michigan Technological University (1977) and has completed studies toward an M.B.A. degree at the University of Colorado. He has extensive experience in the design and evaluation of heap leach facilities; cyanide destruction; liner, cap and cover systems; and in heap leach and tailing facility closure and site reclamation. This experience has been gained through approximately five years previous employment with Anaconda Copper Company in addition to employment as a mining and environmental consultant for the past ten years. His recent experience has included technical critique and comment on a number of proposed mine waste regulatory programs.

REGULATORY AFFAIRS LIAISON: James R. Muhm, CPG

Mr. Muhm will serve as regulatory affairs liaison, and will be responsible for coordination of technical presentations and discussions during the Project Initiation Meeting, as well as coordination of the presentation format for final report findings. His regulatory and public affairs background, coupled with a technical educational background will help to establish a

Figure 1: Project Organization
Oregon DEQ Technical Advice on Mining
Rules



credible communication flow between interested parties and the technical consultant for this sensitive rulemeking review process.

Mr. Muhm is a Certified Professional Geologist with over forty years experience in regulatory affairs and community relations. He holds a B.S. degree in Geology from the University of Wyoming (1950). He is skilled and experienced in working on mining rule development programs, having recently been a major participant in a cooperative rulemaking effort under contract to the state of Minnesota. His experiences on that effort, culminating in the 1990 publication of "The Report on the Mining Simulation Project (Non-Ferrous Mineral Project)" entailed a comprehensive, cooperative effort between representatives of the environmental community, the mining industry, the Minnesota Department of Natural Resources, and the Minnesota Pollution Control Agency. Central to the study was testing of the regulatory program on three hypothetical mining developments in environmentally sensitive areas; consensus based conclusions were reached on aspects of all major issue areas, two of which focused on issues of importance to the Oregon rule making effort, water quality concerns and closure/post-closure design issues. He was subsequently engaged in a similar regulatory development program under contract to the state of Maine, for development of a statewide non-ferrous metallic mining regulatory program.

TASK MANAGER - LINER AND LEAK DETECTION SYSTEMS: Richard V. Beck, P.E.

Mr. Beck will serve as Task Manager for evaluation of liner system design criteria and in addition, will provide support on geotechnical aspects of the tailing and heap leach treatment evaluation as well as the tailing and heap leach closure task. As a geotechnical engineer, he has extensive experience in the design and construction of mining and solid waste facilities, including all aspects of liner and leachate collection systems, tailing impoundment facilities, and cap and cover systems for facility closure.

Mr. Beck is a Registered Professional Engineer with over fifteen years experience in all aspects of solid waste management facility geotechnical design and construction. He holds a B.S. degree in Physics from Elmhurst College (1975), a B.S. degree in Civil Engineering from Tri-State

University (1977), and an M.S. in Civil Engineering (Geotechnical) from the University of Colorado (1983).

TASK MANAGER - MILL TAILINGS TREATMENT: Gerald V. Jergensen, II

Mr. Jergensen will serve as Task Manager for evaluation of mill tailings treatment through cyanide removal and re-use and evaluation of geochemical transport mechanisms relating to metals and acid generating potential. As a mineral processing engineer, Mr. Jergensen has extensive experience in process chemistry and design and evaluation of heap leaching and tailing treatment operations.

Mr. Jergensen holds a B.S. degree in Minerals Engineering from the Colorado School of Mines (1965), and an M.B.A. degree from the University of Colorado (1972). He serves as an adjunct professor of Metallurgy at the Colorado School of Mines.

TASK MANAGER- HEAP LEACH AND TAILING FACILITY CLOSURE: James M. Beck, P.E.

Mr. Beck will serve as Task Manager for evaluation of heap leach and tailing facility closure criteria. He has extensive experience in the design of cap and cover systems for closure of heap leach pads and tailing impoundments. In addition, as an environmental consultant, he has been involved in the design and technical evaluation of a number of low-level radioactive waste disposal facilities incorporating earthen cover systems. One of the more critical aspects of radioactive waste cover system designs is longevity, or cover system performance over time, which also appears to be a central issue in the Oregon rule making effort.

A brief synopsis of Mr. Beck's credentials is provided above.

Due to the inter-relationship of many components in these technical issues, it is anticipated that all team members will perform in a support role on other Task issues. Complete resumes for each individual are provided in Section 3.0.

1.3 Disclosure of Conflicts of Interest

TRC has no significant identifiable conflicts of interest pertaining to this effort. TRC has historically provided professional consulting services to regulatory agencies and industry clients alike, while always striving to mitigate potential conflicts of interest. This has generally been accomplished through keeping regulatory agency assignments restricted to roles similar to the subject study, i.e. regulatory development guidance, regulatory review, etc., as opposed to functioning in a clearly defined enforcement role. TRC has historically performed significant proportions of professional services to mining (and other) industry clients, however, we are not able to identify any direct conflicts with respect to being under contract or other influence associated with: a.) Direct proponents of mining project development within Oregon; b.) Mining companies, mining industry groups, or environmental groups active in working on mining regulations and permitting in Oregon; or, c.) Entities holding direct interest in property in Oregon.

As indicated, TRC has historically performed professional services to the mining industry, and as such, professional staff have credentials and associations that would be not unexpectedly related to mining educational backgrounds, professional association affiliations, etc. TRC is of the opinion that due to the specialized technical expertise required to evaluate regulatory aspects pertaining to mining operations, it is precisely these attributes that will be essential in obtaining meaningful completion of the study. Nevertheless, TRC provides the following disclosures of what may be perceived as potential conflicts of interest by various interested parties. All of the following disclosures are related to project personnel, rather than corporate conflict potential, therefore, we would anticipate that perceived conflicts would not be significant.

1.) *James M. Beck, P.E.; Project Manager*, is an elected officer of the Colorado Mining Association (Vice Chairman of Environmental Affairs) and an elected member of the Board of Directors of that Association. Mr. Beck is also a member of the Northwest Mining Association and the Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers (SME-AIME).

2.) *James Muhm, C.P.G.; Regulatory Liaison* is a member of the Colorado Mining Association and selected Subcommittees of that Association. He is also a member of SME-AIME.

3.) *Gerald V. Jergensen, II; Task Manager*, was formerly an elected officer of the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers (Chairman of the Mineral Processing Division), and is an active member of that society.

1.4 MBE/WBE/ESB Participation

Due to the specialized nature of the technical evaluations required in this effort, TRC has selected primary project personnel based on their respective in-depth knowledge and technical expertise in the required area. TRC was unable to identify primary role subcontract relationships for this effort, however, every attempt will be made, where possible, to procure goods and services in support of this contractual effort, from MBE/WBE/ESB contractors.

Section 2

2.0 DESCRIPTION OF PROJECT MANAGEMENT PLAN

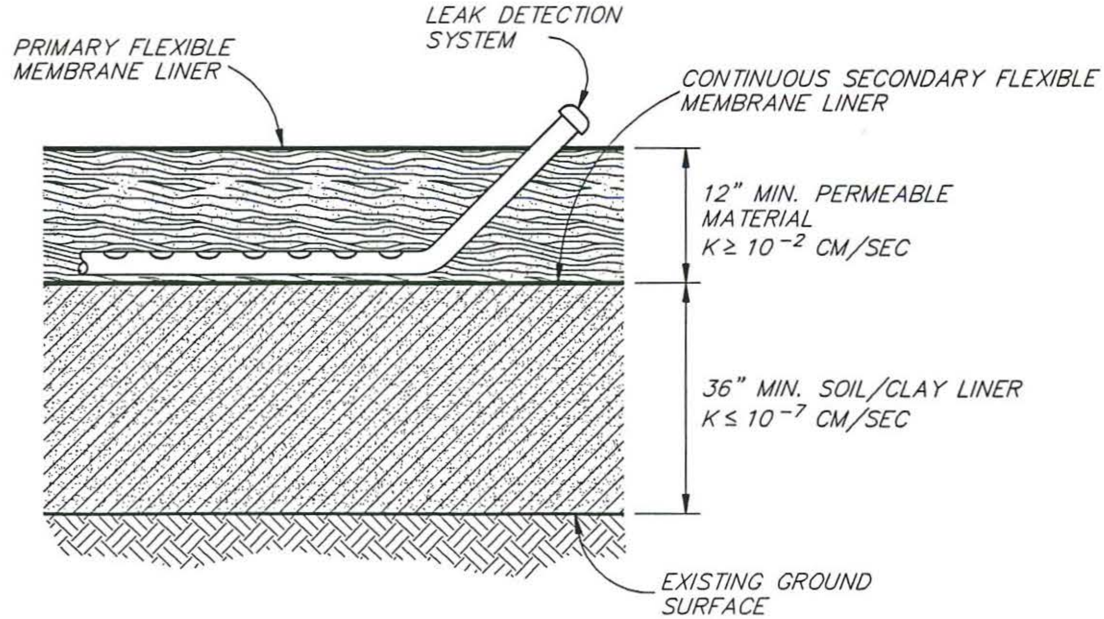
2.1 Issue #1: Liners, Leak Detection and Leak Collection Systems

General

TRC understands that the Environmental Quality Commission (EQC) wishes to evaluate and address four specific technical questions pertaining to liners, leak detection and leak collection systems. These questions are to be evaluated and addressed to determine if two specific liner systems under consideration will meet the stated policy objective of the EQC. In addition, the EQC wishes to determine if other liner systems would meet the stated policy objective. Simple cost comparisons are also to be provided for installation of the various liner systems. The two liner systems to be evaluated by the EQC are described as follows:

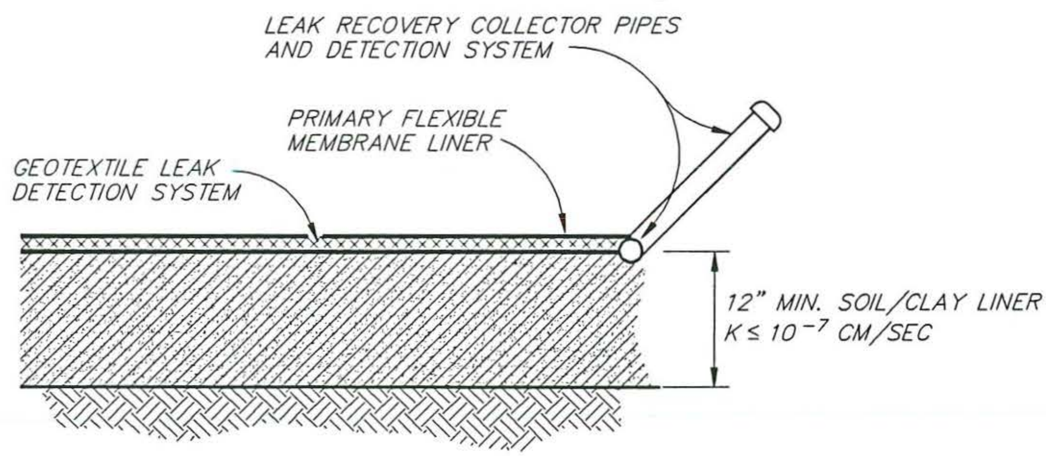
- A triple liner system (Figure 2A) with a leak detection system situated between the two continuous flexible membrane liners (FML's) located in 12 inches of permeable material possessing a minimum permeability of 10^{-2} cm/sec. The leak detection system shall be capable of detecting a leakage of 400 gallons per day per acre within a ten week period of leak initiation. The third liner shall consist of a minimum thickness of 36 inches of low permeability soil/clay possessing a maximum permeability of 10^{-7} cm/sec; TRC understands that this liner's system components are in conformance with proposed rule OAR 340-43-065(4).

- A composite two-liner system (Figure 2B), as proposed by the Oregon Mining Council, consisting of a low permeability (10^{-7} cm/sec) soil/clay bottom liner of minimum 12 inch thickness beneath the upper continuous FML. The two liners are proposed to be separated by a geotextile layer tied to collector pipes spaced at appropriate intervals to detect leakage within the prescribed 10-week period of time.



2.a) PROPOSED RULE 340-43-065(A) LEACH PAD LINER

(NOT TO SCALE)



2.b) OREGON MINING COUNCIL PROPOSED LEACH PAD LINER

(NOT TO SCALE)

PREPARED FOR:
STATE OF OREGON DEQ: TECHNICAL ADVICE ON MINING RULES

PREPARED BY:
TRC Environmental Consultants, Inc.

LINER SYSTEMS TO BE EVALUATED

FIGURE 2

TRC's proposed approach for evaluating and addressing each of the liner system questions is presented in the following subsections.

Approach

TRC has developed an approach which evaluates and addresses each of the four liner system questions, individually, utilizing TRC's knowledge and expertise, as well as published information and technical data currently available and related to each question. Sources of information and data anticipated for review include those publications available from the EPA and other regulatory agencies as well as the Geotextile Research Institute (GRI), the Society of Mining Engineers (SME), the American Society of Civil Engineers (ASCE), and other pertinent publications.

TRC's approach for evaluating and addressing each of the four liner system questions is as follows:

Question (1): Are each of the various liner systems proposed, technically feasible?

Approach to Question (1)

TRC proposes to address this question by evaluating for each of the liner systems their expected performance characteristics, feasibility of construction, and ability to be operated/maintained and repaired.

Performance Characteristics Evaluation

- Evaluation of the proposed leak detection and collection system to detect and recover 400 gallons/day/acre of leakage within 10 weeks of leak initiation.
- Evaluation of the deterioration potential of the leak detection and collection systems functionality due to clogging, increases in surface loading from heaped ore material and environmental factors with time.

- Evaluation of the ability, capacity and ease of operation of the leak detection and collection system to be utilized for remediation purposes in the event that a leak through the primary liner would occur.

- Evaluation of the use and functionality of the leak detection and collection system to identify location(s) of leakage within the primary liner, to minimize disturbance to the liner systems in the event repairs are necessary.

- Evaluation of the liner systems' abilities to comply with the permeability requirements as prescribed by EQC policy.

- Evaluation of geotechnical considerations with respect to each liner system including strength, stability, potential for slippage and settlement considerations.

- Evaluation of the liner system design with regard to providing sufficient factors of safety in the system design and operation in the event distress to the system occurs.

Construction Feasibility Evaluation

- Evaluation of those quality assurance/quality control (QA/QC) considerations that would be necessary for successful construction of each liner system. The evaluation would give indications of the level of complexity to be expected in constructing each liner system and the potential for problems arising due to the limitations and variances in the construction processes. This evaluation would indicate whether one system could be expected to be constructed more reliably than another system.

Operational/Maintenance/Repair Potential Evaluations

- Evaluation of the ease of operation maintenance and repair of the liner systems, including the leak detection and recovery systems.

- Evaluation of the ability of the liner systems to be expanded or be constructed in stages with ongoing ore deposition and pad expansion.

- Evaluation of the long term post closure maintenance considerations of the liner systems after operations have ceased as well as decommissioning considerations which may affect the liner systems' functionality.

Question (2): Will each of the various liner systems meet the stated EQC policy?

<u>Approach to Question (2)</u>

Based on the evaluations performed to address Question (1), potential and/or obvious "fatal flaws" in the liner systems may be identified with respect to complying with the stated EQC policy. Obvious fatal flaws will be considered just cause to show a liner system is in non-compliance with the stated policy objectives. Potential fatal flaws will be further investigated by developing situations or scenarios to test further the potential of the liner system(s) to be flawed. These situations would further test the system's performance, constructability, and operation/maintenance and repair capacities, depending on the component(s) of the system under scrutiny. Once the fatal flaw analysis is performed it will be determined whether or not a liner system meets the stated EQC policies.

Question (3): For those liner systems which will meet the stated EQC policy, what level of certainty would be assigned to each system?

<u>Approach to Question (3)</u>

Those liner systems which have been deemed as meeting the stated policy will be further analyzed with regard to their reliability. This analysis will involve ranking or rating the expected reliability of both the integrated and individual components of each liner system with respect to functionality, constructability, maintenance, operational ease and repair potential. A review of the literature to ascertain the reliability or level of certainty of similar liner systems will also be conducted to aid in the analysis. Based on the results of the rankings and appropriate weighting factors, a level of certainty will be assigned to each liner system.

Question (4): Are there other liner systems which will achieve this policy and what level of certainty for achieving this policy would be assigned to each?

Approach to Question (4)

Based on the review of the literature and product information literature, TRC will investigate the applicability of alternative liner systems, in addition to the two systems already considered. TRC will evaluate one (1) additional "best candidate" liner system to determine if it is in compliance with EQC policy. The evaluation and assignment of the level of certainty would be performed using the same methodology as carried out for the other two liners. The alternative liner would then be able to be compared to the other two liners due to utilization of similar evaluation procedures.

Simple Comparison of Typical Costs for Installation of Various Liner Configurations

TRC will provide estimated costs for installation of those liner systems evaluated, for comparative cost analysis. The estimates will include the material, equipment and labor costs to install each liner system only, on a per square foot or per square yard basis. Other associated costs such engineering and administrative fees, permitting fees and land use fees, etc. will not be considered as part of the estimate. It should be noted that the costs will not be used as part of the evaluation or ranking procedures to assign levels of certainty, but will be presented autonomously.

However, the costs may be useful for future financial or cost-benefit analyses since these analyses are not proposed to be considered as a part of this study.

2.2 Tailings Treatment to Reduce the Potential for Release of Toxics

The EQC commission intends that the toxicity and potential for long term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment.

Cyanide has been used in the gold mining industry for over 100 years. The chemistry and environmental fate of cyanide has probably been the subject of more research and literature than any other mining reagent. Cyanide solutions are also extensively used in industrial plating, metal washing and electronics manufacturing operations. Because of this widespread use, a number of methods have been developed for treating cyanide waste solutions.

Most of the treatment techniques involve destruction of cyanide, in solution, to achieve concentration standards as required by various water quality standards. Well known processes for chemical oxidation include alkaline chorination, hydrogen peroxidation and sulfur dioxide conversion. Each process is capable of reducing cyanide levels to the Federal drinking water standard of 0.2 mg/l. The selection of the actual process therefore becomes an engineering and financial decision.

Cyanide recovery and/or regeneration processes have also been applied with various levels of success. The most well-known process is known as AVR (Acidification-Volatilization-ReNeutralization). Other removal processes involve ion-exchange, chemical conversion and regeneration, solvent extractions and physical adsorptions. Biological oxidation technology is in development at the Bureau of Mines and a commercial biological oxidation process is being marketed by Homestake Mining Company.

This study will focus upon AVR technology. Chemical conversion and regeneration procsses will be reviewed and examined in more detail if a preliminary review indicates possible technical feasiblity.

The general approach will evaluate:

1. Potential processes;
2. Technical feasiblity;

3. Conditions required to meet 30 ppm std.;
4. Factors that favor or preclude commercial application;
5. Impact upon long-term cyanide or toxic metals release; and
6. Level of certainty (long-term industry and regulatory experience with technologies).

Removal technology will be compared to chemical oxidation methods to determine (or identify) alternatives that may effectively achieve the policy of the commission.

Question 1: Are removal and reuse technically feasible?

Approach

TRC proposes to address this question by identifying and describing one or more processes that remove cyanide from the tailings stream. TRC interprets "removal" to mean physical isolation from the liquid fraction of the tailings of soluble (and weak-acid-dissociable) cyanide.

TRC further assumes that "reuse" means the reintroduction of the "removed" cyanide compound into the process. However, sale for other beneficial use or disposal to a permitted TSD may be a possibility. TRC will conduct a review of mining industry practice and experience and reported research efforts. We will identify:

- Technical definition
- Pilot plant, semi-works and commercial experience with locations and references
- Required materials of construction and expected performance

Question 2: Do removal and reuse materially reduce the toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

TRC proposes to evaluate anticipated process performance of various cyanide removal and/or destruction methods. Evaluation of long term responses will depend upon information available from similar operations, if any. General conclusions from other gold mining operations will be applied to projections of future responses.

Question 3: What is the level of certainty to conclusions?

Level of certainty will be dependent upon information available, however TRC will attempt to compile actual operating data, if possible to enhance the level of certainty.

Question 4: Are there other tailings treatment technologies which will equally, or more effectively, achieve the policy of the EQC?

Chemical destruction methods may provide immediate, proven, technologies to achieve the EQC's goals. However, emerging technologies, in combination with recovery and reuse or destruction (such as bio-oxidation) may warrant evaluation.

2.3 Issue #3: Closure of Heap Leach and Tailings Facilities

General Overview

TRC understands that it is the EQC's intent to evaluate three particular aspects related to design of closure methodologies for heap leach or tailings facilities. Primarily, concerns are focused on the appropriateness of three specific proposed rules (Rule Numbers 340-43-080(4)(a); 340-43-080(4)(b); and 340-43-080(5)) which respectively incorporate the following provisions: 1.) Heap leach detoxification over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The weak acid dissociable (WAD) cyanide concentration in the rinsate shall be no greater than 0.2 ppm.; 2.) Heap leach closure by covering the heap with a cover designed to prevent water and air infiltration; and, 3.) Tailings disposal facility closure through installation of a composite cover system designed to prohibit water and air infiltration and be environmentally stable for an indefinite period of time. Evaluation of these three proposed rules will center on evaluating the effectiveness of detoxification (cyanide removal by rinsing) of the heap and covering of the heap and tailings facility to exclude air and water, materially reducing the likelihood of any release to the environment of toxic chemicals and metals contained in the heap over the long term.

Approach

TRC's approach to evaluating and addressing issues central to the above-described proposed rules will be heavily dependent on TRC staff knowledge, expertise, and experience in the design, implementation and/or installation of facility closures of a like or similar manner; review of published information and technical data currently available; and review of closure technologies currently employed in other states. As part of the latter, TRC will attempt to determine performance of closure technologies stipulated in other states, however, we would anticipate that limited data may be available due to the fact that very little is known about the long-term performance of such closure mechanisms. There are two primary reasons; first, because comprehensive closure criteria have only recently been applied statutorily, and secondly, heap leaching of precious metals generally did not play a major role in U.S. mining practices until as recently as 15 years ago. On the other hand, cyanidation has been utilized since approximately the turn of the century, and considerable knowledge has been gained as to the long-term effects of air and water intrusion into cyanide-laden tailings. The following are considered primary cover system evaluation criteria:

- Reduction of water input into heap from precipitation and snow melt;
- Reduction of dilution of Cn;
- Potential anaerobic condition and implication with respect to oxidation potential;
- Reduction in evaporation potential of more tightly held solution;
- Reduction in ability of CN gas or other gasses developed to be released from the heap;
- Increase in stress due to construction of cover and increased pore pressures and pressure gradients through liner to spread or disperse solution into environment;
- Effect of earthen liners versus synthetic liners and their viability over the long term, e.g. cracking, leaking UV radiation, shrinkage, expansion, etc.
- Constructability, reclamation, and erosion potential as well as maintenance of holes from animals, vegetation, etc. through cover.

TRC anticipates that it will be necessary, to establish a credible review, to separate the issues pertaining to residual cyanide, and toxic metals transport, when conducting a review of the proposed rules on heap and tailings closure. This is due to the fact that metals and cyanide compounds have different attenuation mechanisms and varying toxicity effects, both of which are dependent upon metallurgical processes employed, as well as numerous site-specific parameters.

Question (1): Are detoxification and covering (as prescribed in this rule) technically feasible?

<u>Approach to Question (1)</u>

TRC proposes to address this question through coordinated effort resulting from analysis of Issue Number (2) in combination with geotechnical examination of representative cover systems. Detoxification will be evaluated for prospective feasibility as the main emphasis in Issue Number (2), and findings resulting from that phase of the study will provide insight into the technical aspects of detoxification. Sufficient data is readily available from operating facilities as well as through research documentation to evaluate technical feasibility of rinse/rest cyclic detoxification. The primary emphasis on TRC's evaluation of detoxification feasibilty will therefore likely be related to evaluation of the target concentration level of 0.2 ppm WAD cyanide, within the context of achievability.

Cover system evaluation will be based on representative design criteria, with a perspective toward evaluation of the feasibility (practicality or desireability) of "preventing" water or air infiltration into the closed unit. We would anticipate that such an evaluation would involve an assessment of the field achievability of anticipated unit construction permeability coefficients and the relationship of those permeability coefficients to long term effectiveness. Long-term effectiveness assessment criteria would include, but not be limited to, climatic conditions (susceptability to degradation due to precipitation, drying, freeze/thaw, etc.), disturbance due to wildlife (vector) intrusion, and potential chemical alteration of cover materials. Geotechnical evaluation criteria would include considerations of the representative cover design(s) including strength, stability, potential for slippage, and settlement conditions.

Question (2): Do detoxification and covering (evaluated separately and together) materially reduce the likelihood of a release of toxic chemicals and metals to the environment?

Approach to Question (2)

TRC anticipates that this evaluation will be closely related to the activities and findings resulting from evaluation of Question (1), above. Once technical feasibility is established (assuming that it can be accomplished), evaluation of the two closure technologies can be carried out on a stand-alone basis as well as in combination with one another. Since the EQC is interested in specifically evaluating the likelihood of such technologies to "materially" reduce the likelihood of any release to the environment, TRC envisions that some effort will be required to more clearly evaluate the terms "materially", "release" and "environment", particularly for the evaluation of the tandom technology evaluation. It would seem appropriate to evaluate or define these terms within the context of commonly accepted definitions in recognized regulatory statutes pertaining to chemical constituents and/or contaminates identical or similar to those encountered in heap leaching and flotation processes (in the case of tailings). It will also be necessary to examine issues pertaining to exposure pathway and risk-related parameters, i.e., what constitutes an exposure of a significant "unacceptable" level versus an "acceptable" level. We would anticipate that this particular question will constitute an extremely sensitive issue when taken under consideration by all concerned parties, however, TRC is of the opinion that this approach is the sole, available objective approach. To assume statutory "zero-risk" criteria in combination with statutory imposed design criteria consistent with RCRA Subtitle C, will by definition "materially reduce the likelihood of any release to the environment", however, such an approach may (or may not) be totally warranted when considered within the context of the characteristics and types of contaminates involved. TRC therefore, would propose inclusion of such an analysis as part of the Question (2) issue, with the objective of utilizing information gained to objectively complete the analysis of Question (3), below.

Question (3): What is the level of certainty you give to the answers provided above?

Approach to Question (3)

TRC's approach to determination of the level of certainty in the answers to Questions (1) and (2) will be based on a probability/risk assessment weighting of the parameters involved. These parameters will include proposed statutory technical criteria, characteristics of the contaminates, and determined representative considerations pertaining to "indefinite" and "long-term". As discussed above, these considerations will be heavily dependent on interpretation of certain terminologies and/or definitions. As such, TRC will attempt to provide a determination of the level of certainty for the broad spectrum of design considerations, ranging from a technically conservative approach to a technically liberal approach.

Question (4): Are there other technologies which can equally or more effectively achieve the policy of the EQC?

Approach to Question (4)

TRC will attempt to identify and evaluate variants on the proposed technologies that are considered to be within the range of acceptability criteria to meet the EQC's objectives. To introduce entirely different technologies at this point in time would introduce another series of concerns to the regulatory promulgation process. Suffice it to say that it is highly likely that other technologies that may be introduced would be unproven, prototype technologies that would require a long term evaluation process, potentially negating the positive aspects of moving forward with effective and meaningful regulatory action at this time. While variations on the technologies currently under consideration are potentially applicable, broadening the focus on exploratory evaluations at this time would serve no beneficial purpose.

2.4 Public Meeting

Initiation Meeting

TRC anticipates that a single meeting of approximately on-half day's duration in the Portland area will be necessary to initiate the study and will serve as an effective technique to assure that a meaningful study will be conducted. The purpose of this meeting will be two-fold: to provide a discussion of the TRC approach; and to elicit comment from parties interested in the rulemaking proceeding. TRC will be interested in receiving first-hand comment on the proposed approach, to enable incorporation of concerns into the evaluative process. An information exchange will provide the mechanism for full understanding of the issues that may not be adequately addressed in the approach provided in this proposal. While it is premature at this time to determine content, TRC is of the opinion that such a meeting will be most beneficial if a brief summary of the intended approach is provided in advance of the meeting to all parties given notice. This will generally lead to more informed dialogue and lessen the potential for surprises to occur due to what may be perceived (rightfully or otherwise) as a "new" approach or different from what may be expected.

As stated in Section 1.0, TRC intends to incorporate a Public Relations Liaison into its project team. This strategy has been selected to ensure that the initiation meeting is carried out with a productive and positive demeanor. TRC is fully aware of the sensitivity of issues involved to the various parties to the proceedings, and is equally cognizant that any contractor selected for purposes of review will in all probability be suspect in the opinion of one or more parties. For this reason, we feel that it is critical to involve a professional public affairs liaison in the presentation process.

2.5 Logistical Considerations

2.5.1 Project Schedule

TRC proposes to conduct all task issue studies in a concurrent fashion. We anticipate no problem in complying with the project schedule as presented in the Request for Proposal, which incorporates the following dates:

- Participation in Public Meeting within fifteen (15) calendar days of contract execution.
- Draft written report submittal within forty-five (45) calendar days of contract execution.
- Return of a final report within fifteen (15) calendar days of receipt of comments from Oregon DEQ.

Based on the foregoing, TRC would project that, if contract finalization occurs on or before April 15, 1992, draft report submittal should occur on or about May 29, 1992, followed by the DEQ review/comment period. Allowing for a thirty (30) day review/comment period, TRC would be capable of delivering a final report document on or about July 17, 1992.

2.5.2 Work Location

With the exception of the Initiation Meeting to be held in Portland, Oregon (or another designated location to be determined), all work will be carried out in TRC's Denver, Colorado office. Designated contact for all communications regarding this proposal shall be James M. Beck, P.E., Manager, Hazardous Waste Investigation and Remedial Engineering, TRC Environmental Consultants, Inc., 7002 S. Revere Parkway, Suite 60, Englewood, Colorado 80112. Telephone and FAX numbers are (303) 792-5555 and (303) 792-0122, respectively.

2.5.3 Communications

TRC anticipates provision of brief weekly reports to the designated DEQ contract manager, incorporating discussion of work progress, budget status (expenditures to date versus projected budget), and other items as appropriate. Due to the nature of the effort, we would envision routine communications with the DEQ contract manager and technical representatives on a regular basis during the contract period. These may include written memoranda, telephone communications, or facsimile transmittal. TRC will maintain a log of all communications pertaining to this project. A compilation of communications logs will be provided upon DEQ request.

Section 3

3.0 DESCRIPTION OF TEAM MEMBERS EXPERIENCE AND CAPABILITIES

3.1 Regulatory Experience

Specific team member information is provided in Section 1.2.

3.2 Scientific/Technical Knowledge

Specific team member information is provided in Section 1.2.

3.3 Project Experience

All project personnel have extensive regulatory project experience. James M. Beck, P.E., Project Manager, recently concluded the management and technical direction of a third party review of a major landfill expansion application under contract to El Paso County, Colorado. This review was conducted independently to assess the applicant's conformance with technical design criteria stipulated by the Colorado Department of Health to protect affected landowners from groundwater quality impact concerns. The review was completed in a manner that recommended additional investigations satisfactory to all parties.

In another example, he was a primary technical contributor to a third party independent review of the technical sufficiency of a proposed heap leach and mining operation in South Carolina.

Specific TRC project experience is provided herein under the section entitled "Experience".

3.4 Personnel

Resumes for each individual proposed to perform on this contract are provided herein.

Section 4

The following are representative project experience descriptions.

- *American Mining Congress - Industry Superfund Site Evaluations*

  TRC, under contract with the America Mining Congress (AMC), conducted a three-phased study of the 17 mining sites listed on the National Priorities List (NPL) and 14 additional mining sites nominated, but not ultimately listed. Phase I involved the review of each of the above sites, determination of the reasons for each site's listing cataloging the "Human Health" or environmental effects, and a review of mining and waste disposal practices at each site. Phase II was a detailed evaluation of mining operational and waste management practices that the mining industry used between 1800 and 1900, 1900 to 1965, and 1965 to the present. Phase III of the work involved the assessment of the Mitre model and its application to each site listed as well as the 14 sites nominated, but not actually listed on the NPL.

- *American Mining Congress - Health Risk Assessment of Mining Sites*

  TRC conducted a multi-phased contract addressing various health, toxicological, and risk issues relevant to mining sites on the National Priority List and their impact on the environment.

  The contract consisted of the evaluation of the 17 mining sites listed on the NPL and 14 mining sites nominated but not ultimately listed. The specifics of this work included risk assessment, pathway evaluation (ground water, surface water, air, and direct contact), toxicological and health effects, and ground water modeling. TRC is presently evaluating the health effects of the wastes associated with the mining industry through a program that will analyze and model the chemical transport in the environment and assess health effects and risk associated with the mining industry's waste management practices.

- *Confidential Client - Audit of Mining Operations and Review of Tailings Pond Control Systems - Wyoming*

  TRC performed an environmental audit of mining and ore processing facilities to determine whether regulatory obligations were being met. TRC engineers reviewed the methods used to control seepage from a large tailings pond and assessed the likelihood of long term environmental degradation. TRC was able to offer suggestions to assist with environmental compliance.

- *Confidential Client - Preliminary Evaluation of Methods to Control Seepage from Historical Tailings Impoundments - Missouri Lead Belt*

  TRC was elected to select and evaluate practical methods for controlling seepage from tailings impoundments. TRC evaluated the constituents within the water emanating from the impoundments and identified the methods to be used for control. Selection of appropriate methods was based on cost, degree of treatment, and compatibility with the environment.

- *Historic Mining District - Oklahoma*

  TRC served, on behalf of a client, on a technical committee advising the Governor's Task Force on the RI/FS on one of the first and largest NPL sites. The assignment included multi-year participation in the technical review of the workplans and investigation of a number of contractors and agencies, keeping the client informed of progress and problems, and technical input to achieve a practical and cost-effective solution to the remediation and control of acid mine drainage in one of the largest historic mining districts.

- *PRP Technical Support - Smuggler Mountain Superfund Site - Aspen, Colorado*

  TRC has performed specific tasks to assist the Smuggler Mountain Superfund Site PRP's in selecting and ultimately implementing the most cost-effective approach to the site remedy, as specified by the US EPA Record of Decision for the site. Specifically, TRC carried out an engineering cost estimate for Operable Unit No. 1, to determine potential costs of the remedy, the effects of varying unit prices and soil volumes on overall costs and areas where cost savings could be realized. In addition, TRC inspected a boulder pile on the site and assessed the stability of the pile based on historic data and knowledge of rock pile stability. A demonstration of the integrity of the pile, allowing it to be left in place, could significantly reduce the cost of the remedy.

- *Confidential Client - Mine Tailings Remediation - Utah*

TRC evaluated and coordinated a study for the removal of mine tailings that had migrated off-site and several miles along a stream channel. The study was conducted in accordance with the NCP for possible third-party cost recovery. The tailings contained elevated concentrations of heavy metals. The study was designed to remove the tailings based on visual characterization to reduce burdensome analytical costs.

- *Western Mining - Environmental Assessment - Colorado*

TRC conducted an environmental assessment for an Australian mining company considering the purchase of an operating mine with acid mine drainage problems in southwestern Colorado. The principal concern centered on the fact that the facility owner had been named as third party defendant in a Natural Resources Damages Claim by the State of Colorado under CERCLA. It was determined that there was no technical basis for the operations at this property to adversely affect resources in the surrounding area subject to the law suit.

- *ASARCO, Inc. - Remedial Investigation/Feasibility Study for Metal Smelting and Refining Facility - Denver, Colorado*

TRC is managing a major, multi-disciplinary environmental investigation for ASARCO at one of its smelting and refining facilities in Denver, Colorado. Subject of a $50 million plus lawsuit under CERCLA, the site covers over 90 acres with large slag and tailings deposits and has been in operation since 1886. TRC is directing the work of a team of hydrology, soils, vegetation, aquatics and environmental health consultants at the site, providing direct technical input, overseeing investigations, reviewing work product, developing work plans, and acting as official liaison with the Colorado Department of Health and their consultants. Investigations have included extensive groundwater contamination studies, water and sediment sampling in a several mile long segment of the South Platte River, soils and vegetation sampling and surveys in a two mile radius of the site, and ambient air quality monitoring. TRC staff were instrumental in helping ASARCO and their legal counsel reach agreement with the State on a cooperative study, thus reducing legal costs and ultimate investigation costs while allowing the client to retain control of the study.

TRC is also conducting a feasibility study to evaluate various remedial alternatives at the site, including slurry walls, interceptor drains, groundwater recovery wells, waste pile caps, on-site landfills meeting RCRA standards, and soil treatment.

- *Gold Fields Mining - Permit Applications - Colorado*

  TRC performed initial permitting feasibility studies, and obtained the Exploration Permit for an underground precious metals mine in Eagle County, Colorado. The permit application included an analysis of the impact of exploration on soils, water, vegetation, and air quality. Additionally, TRC prepared an environmental assessment report which was subsequently reviewed and approved by the County Government.

- *Confidential Client - Develop a Cleanup Plan to Remove and Dispose of Process Wastes and Tailings from a Minerals Processing Facility - Wyoming*

  TRC is developing a plan to remove process wastes and tailings from a minerals processing facility. The cleanup plan will organize and prioritize the proper disposition of materials on and from the site. Materials will be categorized according to their chemical characteristics and regulatory status. Appropriate disposal options and costs will be assessed. Regulatory considerations regarding RCRA, CERCLA, and Bevill will be included in the plan.

- *AMSELCO - Colosseum Gold Mine - California*

  TRC prepared the emissions inventory, summary of modeling results, and full air quality permit application for AMSELCO's Colosseum Mine. Using fugitive dust emission factors specifically applicable to precious metals mines, fugitive dust emission rates from all mining activities were computed and allocated to area sources for modeling. Predicted concentrations were shown to be less than applicable TSP and PM10 standards, and a New Source Review Permit was granted to AMSELCO by San Bernardino APCD.

- ***Lead-Zinc Mine and Mill - New Mexico***

  TRC represented a client during investigations by and negotiations with the State of Department of the Environment. The state investigation of closed facilities was for the purpose of evaluating possible environmental impacts for possible inclusion of the site on the National Priorities List. No enforcement action resulted.

- ***Steel Strip Manufacturer - Wastewater Treatment/Sludge Handling***

  TRC performed wastewater treatment evaluations for a steel strip manufacturer. These studies included: 1) upgrading an oil/water separation system, 2) examining disposal options for buffing sludge, 3) designing a treatment and/or recycling system for acid and alkaline cleaning wastes, 4) developing disposal options for oil sludges, and 5) updating an oil/hazardous substances SPCC plan. The initial studies included problem definition, an evaluation of the cost-effectiveness of alternative systems, and conceptual design. Later phases involved detailed plans and specifications for new equipment and installation.

- ***Steel Mill Pickle Liquor Process - RCRA Delisting Petition and Upgrading of a Treatment System***

  The effluent from a pickle liquor treatment system was violating permit guidelines for solids and heavy metals. TRC upgraded the treatment system beginning with a series of jar tests to determine the optimum neutralization chemical. Later, equipment modifications were recommended to improve flocculation and sedimentation.

  TRC also investigated treatment sludge dewatering and disposal and delisting the sludge as hazardous waste under Resources Conservation and Recovery Act regulations.

- ***Specialty Steel Manufacturer - Site Assessment, Initial Design, and Environmental Permitting of a Slag Disposal Landfill***

  For a Connecticut manufacturer of specialty alloys, TRC provided all technical services associated with obtaining necessary environmental permits for the landfill disposal of slag. The work was done in four distinct phases: preparation of a permit plan, site investigations, preparation and filing of permit applications, and follow-up liaison with regulatory personnel. The permit plan phase included meeting with all potentially-involved units of the Connecticut Department of Environmental Protection (CTDEP) to discuss the proposed project, its permit needs, and the procedure and schedule for obtaining each permit. Application formats and necessary supporting data were agreed upon at that time. A report was prepared for client use describing all applicable permits, potential problems, etc.

- *Metals Recovery Plant - Environmental Audit for Property Conveyance*

Prior to planned sale of a secondary metals recovery plant in northern California, A manufacturing firm retained TRC to review necessary environmental regulations which must be met. TRC is conducting an environmental audit to evaluate existing regulations and to identify other potential environmental liability concerns for the client. Important aspects of the audit include reviewing available data on site conditions and plant operations, inspecting the facility, and reviewing historical aerial photographs to evaluate past site conditions.

- *Determination of Arsenic Emissions from Glass Furnaces*

TRC conducted a comprehensive program to evaluate existing test methods and developed a method to determine arsenic emissions at different exhaust temperatures. Simultaneous sampling was performed at different temperatures to determine the difference in particulate/gaseous arsenic ratios and the effects of a control device at those temperatures. Data collected were used to develop a NESHAP arsenic emission standard.

- *Hazardous Emissions from a Metal Forging Operation*

TRC was retained to evaluate the hazardous emissions resulting from the die release lubricants used during the forging operation at a large integrated facility. Tests were done to compare the emissions from water-based and oil-based die release lubricants.

Resumes

JAMES M. BECK, P.E.
PRINCIPAL CONSULTANT AND MINING ENGINEER

EXPERTISE

- Mine Waste Management and Remediation
- Tailings Reprocessing and Stabilization
- Mining Facility Audits and Assessments
- Remedial Alternatives Evaluation

SUMMARY OF EXPERIENCE

Mr. Beck is a registered professional mining engineer specializing in the engineering design, evaluation, and management of mining waste investigation and remediation. With over 14 years experience in all aspects of mining engineering and waste management, Mr. Beck's professional consulting career has concentrated on environmental and waste management consulting to mining clients for nearly ten years, while his previous industry affiliation has included Anaconda Minerals Co. and the associated subsidiaries ARCo Coal Co. and ARCo Australia, Ltd.

Most recently, Mr. Beck has been involved in the determination of the extent of contamination and the design and evaluation of remedial alternatives for mining properties located within the boundaries of large area-wide mining CERCLA (Superfund) sites in the western U.S. A major focus in these efforts has been the evaluation of potential remining and reprocessing methods for waste rock, tailings, and sub-grade ores in combination with employing traditional remedial measures such as diversion structures, stabilization, and cap and cover systems. Additionally, he has been responsible for evaluations of environmental liabilities and hazards related to acquisitions and divestitures associated with proposed, inactive and operating facilities, as well as technical evaluations for permit requirements, environmental assessment (EA) documents, reclamation bonding, and corrective actions related to compliance issues or violations.

As a consultant, Mr. Beck has completed a wide range of assignments on behalf of mining clients, legal counsel, and financial institutions. These include design of low-level radioactive processing residue cleanup plans and disposal cells, development of heap leach facilities for precious metals recovery, assessment of permit and compliance status for underground and open-pit facilities for most mineral commodities, economic analyses and feasibility studies related to environmental controls, acid mine drainage water treatment, and evaluation of subsidence and other hazards.

While with Anaconda Minerals Co. Mr. Beck was responsible for the evaluation and remediation of inactive precious metals properties in Anaconda's surplus properties inventory. The focus of this effort was to identify those properties with significant potential for environmental liabilities attributable to past mining or processing activity on-site, and to determine the most economically feasible method of remediating the site (usually employing a reprocessing approach) prior to its disposition for redevelopment or other subsequent use. This included identification and elimination of hazards, drilling and confirmation of recoverable reserves in tailings, sub-grade ore or waste dumps and ore stockpiles; coordination of metallurgical testing and optimization for leaching parameters; identifying, agency negotiation, and securing of all required permits; development of water supply systems and utilities to site; and development of site reclamation final contour plans.

Selected Mining Experience

- Silver City Mill Tailings and Smelter Slag, Eureka, Utah - Project manager for development of precious metals recovery operation to remediate environmental concerns associated with airborne dispersion of chloride roast tailing materials. Project involved tailings reprocessing facility design and feasibility studies, metallurgical testing, and permitting for a cyanide heap leach operation.

- Denver Radium (Superfund) Site, Denver, Colorado - Project manager for radium-contaminated soils project at a Superfund site industrial facility. Developed extensive site sampling plans for former radium production facility, risk assessments, remedial action plan, and conducted regulatory negotiation and interfacing. Design engineering of liner and cover system for low-level radioactive waste disposal cells proposed for location atop decommissioned uranium/vanadium heap leach pad.

- Cement Kiln Dust Disposal (Superfund) Sites, Salt Lake City, Utah - Provided conceptual engineering designs of several alternative remedial action methodologies for kiln dust disposal sites impacting area groundwater. Alternatives included variations on clay capping, asphaltic capping and surface stabilization/fixation. Provided economic comparisons of alternatives to methodologies developed in the site RI/FS.

- Golden Cycle Mill, Colorado Springs, Colorado - Developed and managed pre-acquisition due diligence evaluation of potential environmental liabilities associated with the Gold Hill Mesa tailings, formerly the site of the Golden Cycle Mill. Scope of investigation include surface water analyses, implementation of a groundwater monitoring network, and tailing material characterization and analyses.

- Metallurgical Processing Facility, Pahrump, Nevada - Project manager for RCRA corrective action involving regulatory negotiation, site characterization to determine extent of soil and groundwater contamination, and remedial action for abandoned process wastewater lagoons, tailing disposal areas, and slag heaps associated with mineral processing operations. Successfully negotiated cost effective site cleanup addressing heavy metals, WAD and total cyanide, and process chemical disposal concerns.

- Former Carey Salt Mine, Lyons, Kansas - Preliminary investigation of sodium chloride contamination of soils and groundwater due to salt stockpiling and brine evaporation ponds associated with underground salt mine. Also included definition of environmental liabilities associated with former use of the underground workings for experimental radioactive waste disposal operations.

- Bodie Bluff and Silver Hill Claim Groupings, Bodie California -- Conducted pre-acquisition due-diligence evaluation of potential environmental liabilities. Included tailing and dump material analyses, and evaluation of environmental concerns due to previous mining and milling practices.

- Elk Peak Project - Pre-acquisition due diligence evaluation of potential environmental liabilities associated with the Elk Peak Mine and the former U.S. Gypsum Heath Mine and plant, proposed for changeover to a cyanidation plant with underground backfill tailings disposal. Review and recommendations were provided concerning closure/reclamation aspects of Heath property prior to acquisition.

- Gilt Edge Property, Gilt Edge, Montana - Pre-acquisition evaluation of liabilities associated with claim grouping that included the former "Golden Maple" heap leach operation. The Golden Maple operation experienced an overtopping of solution ponds in 1985, resulting in a State of Montana Emergency Order requiring containment and remedial action. Recommendations resulted in exclusion of heap leach area from overall acquisition.

- Yak Tunnel/California Gulch (Superfund) Site, Leadville, Colorado - Provided technical support to litigation by potentially responsible party with respect to claim holdings located within extensive area included in NPL and state of Colorado natural resource damage assessment (NRDA) suits. Project involved characterization of mine waste rock and evaluation of contributions to heavy metal soil contamination, surface leaching of metals, and acidic groundwater concerns in the district that subsequently impact the headwaters of the Arkansas River. Also provided remedial design engineering and economic evaluations.

- Balmat Mines Division, Gouverneur, New York - Performed multi-tiered due diligence investigation of the Pierrepont mine facility, the decommissioned Edwards tailing impoundment, the inactive Balmat No.2 surface facilities and decommissioned tailings impoundment, and the Balmat No. 3 zinc mining/milling operations and tailing disposal facility. Evaluated water quality issues (groundwater and surface discharge of tailings decant water) and other aspects of environmental compliance and provided cost estimates for remedial measures.

- Darwin Mine and Heap Leach, Darwin, California - Pre-acquisition due diligence investigation of mine, mill, decommissioned heap leach, and Merrill-Crowe precious metal recovery plant. Key issues involved standby status of waste discharge permit and determination of inactive/closure status with respect to existing heap leach liner design to maintain operational readiness and compliance. Reviewed laboratory data on residual cyanide levels in heap collected during post-closure monitoring.

- El Plomo Project, San Luis, Colorado - Pre-acquisition evaluation of liabilities associated with claim grouping that included the former "OJ" heap leach operation, site of a 1976 cyanide release due to surface runoff. Release resulted in precedent-setting litigation pertaining to "Point-Source" determinations as applied to heap leach operations. Provided evaluation of permitting requirements and preliminary recommendations for tailings facility siting alternatives for proposed large-scale operation.

- Contaminated Soil Remedial Action, Cheyenne, Wyoming - Project manager for regulatory interfacing (Wyoming DEQ and EPA); characterization and definition of extent of contamination, remedial action, transport and disposal associated with benzene-toluene-xylene contaminated soils from a fire suppression training facility. Project included design and installation of groundwater monitoring network.

EDUCATION

1977 B.S. Mining Engineering, Michigan Technological University
1980 M.B.A. Graduate Studies, University of Colorado

PROFESSIONAL CERTIFICATIONS/AFFILIATIONS

Professional Engineer: Colorado (#25393) Nevada (#7938)
Michigan (#34082) Utah (#8269)
Certified Hazardous Materials Manager (#1150)
Registered Environmental Assessor (California #1150)

SME-AIME, Member
Colorado Mining Association, Director
Vice Chairman, Environmental Affairs Committee
Member, Solid and Hazardous Waste Subcommittee
Northwest Mining Association, Member

PUBLICATIONS

Beck, J. M., "Mining Remedial Actions From a Technical Viewpoint: A Superfund Update", Proceedings from the 97th Annual Northwest Mining Association Convention, Spokane, Washingtin, 1991.

Beck, J.M., Engelking, J.M., and Elder, R.L., "Resource Recovery: An Economic Approach to Remediation", Published in Mining and Mineral Processing Wastes, pp 243-248, SME-AIME, 1990.

Beck, J.M., "Technical and Financial Considerations in Precious Metal Property Acquisitions", Proceedings of the 1989 Engineering and Mining Journal International Gold Expo, Reno, Nevada.

Beck, J.M., "Avoiding the Hidden Costs of Reopening Inactive Mining Properties", Proceedings of the 1989 Multinational Conference on Mine Planning and Design, Lexington, Kentucky.

Beck, J.M., "Regional Hydrogeological Implications on the Property Transfer Assessment: A Case Study", Proceedings of the 9th Symposium on Geotechnical and Geohydrological Aspects of Waste Management, 1987, Fort Collins, Colorado.

Beck, J.M., "Considerations for Alternative Low-Level Radioactive Waste Disposal Sites", Proceedings of the 8th Symposium on Geotechnical and Geohydrological Aspects of Waste Management, 1986, Fort Collins, Colorado.

JAMES R. MUHM, CPG
ENVIRONMENTAL COMPLIANCE SPECIALIST

EXPERTISE:

- Environmental Due Diligence (Phase I) Audits
- Regulatory Affairs/Community Relations

SUMMARY OF EXPERIENCE:

Mr. Muhm is a Certified Professional Geologist specializing in the environmental aspects of mining operations. While serving as Director of Government Affairs for Occidental Minerals Corporation, he developed and implemented one of the first environmental audit programs ever used in the mining industry. Mr. Muhm has conducted more than 50 environmental due-diligence investigations and Phase I environmental audits of mines, associated mills, hot mix asphalt plants and pre-mix concrete plants. His experience as a professional geologist, coupled with his background in mining, enables him to conduct an environmental investigation thoroughly and efficiently. Mr. Muhm is an active member of SME-AIME and the National Association of Environmental Professionals.

- *Topaz Mountain, Utah.* Pre-acquisition environmental due-diligence investigation of beryllium mine site, haul route to mill site, existing groundwater pollution in area of proposed mill site, and potential occupational health hazards within mill.

- *Golden Reward Mine and Mill, Lead, South Dakota.* Environmental due-diligence investigation of permitting probabilities, legislative and regulatory attitudes and expectations, protection of groundwater and surface water resources, accommodation of competing land uses, participation in adoption of acceptable county mining ordinances, and selection of environmental permitting contractor.

- *Five Aggregate Quarries Located in Minnesota, New Mexico and Washington.* Pre-acquisition evaluation of liabilities associated with properties operated by individuals who leased them from major industry owner. Investigations included permit adequacy and permit compliance, potential liability from neighboring properties, potential enforcement action, and site inspections.

- *Meridian Minerals Company Aggregate Quarries and Plants in Wyoming, Minnesota, Oklahoma, Oregon, Montana, Texas and Washington.* Environmental audits included evaluation of permit adequacy, permit compliance and liability associated with facility operations.

- *Yuba Placer, California.* Pre-acquisition environmental due-diligence evaluation of gold dredge operation, extraction circuit and gold recovery mill, and associated silica sand plant and aggregate plant leased to other operators. Major emphasis of site assessment involved liabilities of former municipal landfill and industrial wastes from dredging, and occupational health considerations.

- *Four Quarries and Two Processing Plants, British Columbia.* Environmental audits focused on permit compliance, regulatory concerns, and occupational health considerations.

- *Solano Concrete, California.* Pre-acquisition environmental due-diligence investigation of aggregate quarry, hot mix asphalt plant, and pre-mix concrete plants. Evaluated liability of surface water and groundwater pollution, protected species, existing rights-of-way, petroleum and lube management practices, and an evaluation of citizen initiatives.

- *Platoro Mine and Mill, Colorado.* Prepared environmental portion of feasibility document preparatory to bank financing. Environmental investigations of gold mine and mill included permit status, adequacy of treatment of mine drainage and suitability of candidate mill tailings sites.

- *Complex of Seven Dolomite Quarries and Processing Plant, Washington.* Environmental audits included permit adequacy, waste management, occupational health considerations and adequacy of mine planning.

- *Cities Service Copper Company, Miami, Arizona.* Environmental audit for seller. Investigation included permit adequacy and permit compliance, site assessments, and evaluation of community relations.

- *U.S. Antimony, Townsend, Montana.* A pre-acquisition environmental due-diligence investigation of an antimony mine and mill, and of Idaho gold properties and a mill. Assessment included permit adequacy and compliance, occupational health considerations, and potential legislative and regulatory constraints on future productions.

- *Ridgeway Mine and Mill, South Carolina.* Environmental due-diligence investigation of a gold mine and mill, permit compliance, regulatory attitudes, future operational constraints, environmentally related financial obligations, and an assessment of community relations.

- *Wing Hill Garnet, Rangeley, Maine.* Environmental due-diligence investigation of an industrial garnet mine and mill. Assessment included permitting requirements, haul route evaluation, suitability of the mill, and community attitudes.

- *Green Mountain, Wyoming.* Environmental due-diligence investigation of a proposed underground uranium mine, including permitting constraints, mine waste disposal, and protection of groundwater resources.

- *Meridian Minerals Proposed Quarry, Corson, South Dakota.* Participation in formulation of county mining ordinance, presentation of company plans at public hearings, and coordination of permitting effort. Community education constituted a major part of the assignment.

EDUCATION:

1950 B.S. Geology, University of Wyoming

PROFESSIONAL AFFILIATIONS:

SME-AIME
Certified Professional Geologist (#2598)
Registered Environmental Professional (#4018)

RICHARD V. BECK, P.E.
PRINCIPAL GEOTECHNICAL ENGINEER

EXPERTISE:

- Mining and Solid Waste Facilities
- Geotechnical, Hydrologic and Hydraulic Modeling
- Remedial Engineering and Project Management
- Permitting

EXPERIENCE:

Richard V. Beck is a registered professional engineer specializing in the engineering design, evaluation and project management of mining and solid waste facilities projects including heap leach, tailings dam and landfill facilities. Mr. Beck possesses over 15 years of experience as a consulting geotechnical and water resources engineer. He has provided consulting services for various geotechnical, mining, solid waste and water resources consulting firms on numerous projects.

In the mining field, Mr. Beck has been responsible for both the geotechnical and water related considerations pertaining to the design, evaluation and management of heap leach facilities, tailings dam facilities and other related mining facilities. He has been responsible for liner designs and evaluations, slope stability analysis, groundwater and seepage analysis, and pond and major impoundment designs including hydrologic, hydraulic and water-balance analysis and considerations. In addition, Mr. Beck has been responsible for implementing various geotechnical, hydrologic and hydraulic computer programs as part of his consulting experience. He has also been actively involved in the permitting aspects of various mining facilities.

In the solid waste area, Mr. Beck has been involved with the geotechnical aspects of various solid waste facilities, including geotechnical field investigations, slope stability analysis, liner and cover system evaluations and seepage, settlement and strength considerations. In addition, he has been involved with the modelling of leachate conveyance and leachate collection systems pertaining to both proposed facilities as well as remedial efforts for existing facilities not in regulatory compliance. Mr. Beck has also been responsible for surface water control analysis and evaluations for various sold waste sites including diversion channels, sediment ponds, and gravity and pumped storm water conveyance systems. He has also been involved with watershed and floodplain modeling utilizing the Army Corps of Engineers HEC1 and HEC2 computer programs. Mr. Beck has been responsible for the permitting issues of numerous solid waste facilities including conducting periodic site reviews, reports of disposal site information and updates of waste discharge requirements and siting studies, EIS's and EIR's.

<u>Heap & Dump Leaching</u>

- Ridgeway Project, Columbia, South Carolina - Responsible for geotechnical, hydrological, and hydraulic functions pertaining to the design of major heap leach facility projects, including reservoir impoundment facility for water supply to facility and resulting water balance. Involved in geotechnical aspects of liner selection and monitoring systems.

TRC

- Yellow Cat Mine Project, near Winnemucca, Nevada - Responsible for geotechnical, climatological and water related issues pertaining to a heap leach facility in northern Nevada.

- Tonkin Springs Project, Tonkin Springs, Nevada - Responsible for development of climatological, hydrological, and water balance data for large heap leach facility in central Nevada.

- Quartz Mountain Project, Quartz Mountain, Oregon - Responsible for development of climatological, hydrological, and water balance data for major heap leach facility in north central Oregon subject to major precipitation, snowfall and snowmelt events.

- Prairie Diggings Project, John Day, Oregon - Responsible for development of climatological, hydrological, and water balance data for a heap leach facility in south central Oregon subject to major precipitation events in addition to snowfall and snowmelt events.

- San Luis Project, San Luis, Colorado - Responsible for climatological, hydrological, and water related issues for a combination heap leach facility and tailings dam facility in southern Colorado.

- Lavon Project, Cripple Creek, Colorado - Responsible for preparation of groundwater quality baseline data as well as climatological, hydrological, and flood data for heap leach facility in southern Colorado.

- Zenda Mine, Tehachapi, California - Responsible for project management and permitting efforts of a proposed synthetically lined valley leach facility on steeply sloping ground. Due to the "dam-like" nature of the facility, it was necessary to permit the facility through DWR as a non-jurisdictional "dam" by providing a moveable 10,000 year spillway in addition to permitting of the leachate collection system through the CRWQCB.

Solid Waste Facilities Projects Including Liners, Cover and Leachate Collection Systems

- County of Sacramento Kiefer Road Landfill Cover Closure - Responsible for project and construction management of all aspects of final closure and cover to a portion of the County of Sacramento's only major landfill. The project included geotechnical investigation for an onsite cover material source, development of a QA/QC program and preparation of construction plans. The project included an extensive geotechnical testing program for certification of the cover closure materials and construction to the RWQCB.

- County of Sacramento Kiefer Road Landfill Expansion Project - Project Manager responsible for siting of landfill expansion location for County of Sacramento's only major landfill. Responsible for all engineering related issues pertaining to suitable site location selection.

- Durham Road Landfill Expansion Project, Freemont, California - Project geotechnical engineer on a major landfill expansion project in the San Francisco Bay Area. Responsible for investigation of potentially excessive consolidation settlements, liner suitability and the influence of upward gradient groundwater on the landfill's performance. Responsible for the development of a geotechnical testing program to assess the suitability of potential liner systems and leachate collection facilities.

- Nevada County Landfill Remediation and Expansion, Nevada County, California - Project geotechnical engineer responsible for investigation, modeling and remediation efforts for an existing leachate collection system for a landfill in non-compliance with the RWQCB. In addition, was responsible for evaluation of leachate collection, liner and cover systems for proposed landfill expansion and closure requirements. Both liners and covers evaluated, considered synthetic and earthen materials as well as composite materials.

- B & J Dropbox Landfill Permit Revisions and Updates, Solano County, California - Project geotechnical engineer responsible for evaluation of leachate collection system for a solid waste facility permit update and revision including Report of Disposal Site Information (RDSI), Report of Waste Discharge (ROWD) and the Periodic Site Review (PSR).

- City of Willits Landfill Expansion, Mendocino County, California - Project Manager responsible for developing a RWQCB approved plan and approach for expanding a moderately sized landfill in Northern California, potentially to be utilized as part of a Joint Powers Authority. The plan and approach addressed critical issues of stability, liner and cover evaluations as well as leachate collection considerations for the landfill, situated in mountainous terrain and adjacent to a major natural drainage channel.

EDUCATION:

1975	B.S.	Physics, Elmhurst College
1977	B.S.	Civil Engineering, Tri-State University
1983	M.S.	Civil Engineering (Geotechnical Engineer), University of Colorado

PROFESSIONAL CERTIFICATIONS/AFFILIATIONS:

Professional Engineer: Colorado (#23994)
California (#C47057)
NSPE, Associate Member

PUBLICATIONS:

"Performance of the Modified Cam Clay Model for Simulations of Soils Under Different Stress Paths," Fifth International Conference on Mathematical Modeling, IAMM. University of California, Berkeley, California, July 1985

"Optimization Technology of Heap Leach Pad Liner Selection," 116th Annual Meeting of AIME, SME, and TMS, Geotechnical Aspects of Heap Leach Design Symposium and Proceedings. Denver, Colorado, February, 1987

SEMINARS/WORKSHOPS:

1. EPA Seminar - Design and Construction of RCRA/CERCLA Final Covers, 1990
2. U. of Wisconsin - Seminar on Computer Applications to Geotechnical Engineering, 1986

GERALD V. JERGENSEN, II
SR. PROCESS ENGINEER

EXPERTISE:

- Process Development and Design
- Extractive Metallurgy
- Aqueous Chemistry
- Crushing and Grinding Circuit Design

EXPERIENCE:

Mr. Jergensen is a metallurgical engineer specializing in process engineering including process development and design, extractive metallurgy, aqueous chemistry, and crushing and grinding circuit design. His experience has included all major aspects of environmental control such as waste minimization and material recycling/reprocessing, flue gas desulfurization technology, hazardous and toxic materials management and technology development.

Mr. Jergensen's professional career of over 25 years has included employment with a number of major engineering and process design firms as well as process equipment manufacturers. As a consultant, Mr. Jergensen has completed numerous process development and plant design assignments on behalf of major chemical producers and mining firms throughout the world. He is active in SME-AIME, is a past chairman and director of that society's Minerals Processing Division, has authored a number of publications on comminution circuit design, mineral processing, and engineering feasibility studies, and is an adjunct professor of metallurgy at Colorado School of Mines.

- <u>TRC Environmental Consultants, Inc.</u> Application of metallurgical process technology to the design and implementation of environmental control strategies and operating systems. Services include feasibility studies, permit management, engineering management, and construction management.

- <u>Minproc Engineers.</u> Design and construction of environmental control facilities for various metallurgical processes, including secondary lead, molybdenite roasting, copper extraction, and refining. By products of recovery processes included sodium sulfate, sulfuric acid rhenium.

- <u>Cyprus Miami Copper Company.</u> Process audit of leaching, solvent extraction and electrowinning operations. Developed methods for reducing losses of solvents to various recycled and waste streams. Also performed audit of metal hydroxide waste recycling program in smelter operation and "due diligence".

- <u>Phelps-Dodge Corp</u>. Developed process concepts for combined recovery and treatment of process dusts, slags and acid plant blowdown streams. Specified process equipment for crushing, grinding and flotation of slags from an Outokumpu Flash Smelting Facility. Similar work performed for slag grinding at a Noranda Process smelter.

- <u>Confidential Client</u>. Examined processes, products, and by-products for a fully integrated lead-zinc-silver production facility. Developed process models for a concentrator, lead smelter and zinc roasting and electrolytic refining complex. The model was used to identify species, sources and pathways of various metals through the facilities and to support PRP assessments.

- Kerr McGee Chemical Co., Trona Production Facilities. Analysis of applications for sodium compounds in flue gas desulfurization processes.

- Confidential Client. Survey and evaluation of cyanide destruction and recovery processes. Examined processes, capital and operating costs and performance to attain or minimize cyanide content in tailings pond waters and barren solutions.

- Outokumpu, Inc., Denver, Colorado. Application and design of large capacity mineral flotation cells; design and installation of ceramic disc filter system for concentrate dewatering; design evaluation and installation of grinding mill and X-ray instrumentation and controls.

- Newmont Gold Co., Gold Quarry Mine, Carlin, Nevada. Design and construction of crushing plant modifications to increase mill capacity and modifications to flash chlorination processes to improve refractory gold recovery.

- CoBank National Bank for Cooperatives, Denver, Colorado. Evaluation of process waste streams associated with various agricultural process including bulk fertilizer manufacture, storage and distribution, cane sugar refining, cottonseed oil extraction, and food products processing and canning.

- Denver Mineral Engineers, Denver, Colorado. Metallurgical consulting for design and construction of carbon adsorption and stripping processes as related to precious metals recovery circuits. Design/construction and installation of electro-chemical process equipment and metallurgical furnaces. Various project locations throughout the U.S.

- Yukon Placer, Whitehorse, Canada. Feasibility level study of placer gold property. Evaluation of reserve estimates and wash plant design.

- Alma Placer. Alma, Colorado. Technical evaluation of reserves and metallurgical recoveries in support of tax litigation.

- Rosario Resources Corporation, El Mochito Mine, Honduras, Central America. Provided technical evaluation of process flow schematics and equipment specification for mill expansion to 2,500 tons per day at lead-zinc-silver mining operation located near San Pedro Sula.

- The World Bank, Washington, D.C. Comprehensive technical and economic review of the Bolivian minerals industry. Feasibility level studies of conceptual strategies for industry modernization.

EDUCATION:

1972	M.B.A.	Finance, University of Colorado
1965	B.S.	Minerals Engineering, Colorado School of Mines

TRC

TRC Environmental Consultants, Inc.

Windsor, CT / (203) 289-8631 • Mission Viejo, CA / (714) 581-6860 • Denver, CO / (303) 792-5555
Somerset, NJ / (908) 563-1100 • Seattle, WA / (206) 778-5003 • San Francisco, CA / (707) 769-5250
New York, NY / (212) 643-2050 • Troy, NY / (518) 283-8722 • Austin, TX / (512) 328-2410
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• PERMITTING • WASTE ENGINEERING • MAPPING • STRUCTURES

DAVID A. HOPPENS
Civil Engineers

BOX 130
1365 HIGHWAY 21 NORTH
MALO, WA 99150

DAVID A. HOPPENS, PE
509-775-3197

David A. Hoppens
Midnight Systems
Box 130 Malo, WA 99150-0130
509-775-3197

$Q=\int \mu dy$

March 2, 1992

State of Oregon
Department of Environmental Quality
811 S. W. Sixth Avenue
Portland, OR 97204

Gentlemen:

Enclosed please find a proposal for Technical Advice on Mining Rules.

It would indeed be desirable if all States would take the initiative that you people are doing. I am sure that the Citizens of Oregon will appreciate your concerted effort and interest in their welfare.

Thankyou for allowing me to participate in your project.

Sincerely,

David A. Hoppens

David A. Hoppens, PE

INDEPENDENT CONTRACTOR CERTIFICATION STATEMENT *

State agency certifies the contracted work meets the following standards:

1. Contractor will provide labor and services free from direction and control, subject only to the accomplishment of specified results.
2. Contractor is responsible for obtaining all assumed business registrations or professional occupation licenses required by state or local law.
3. Contractor will furnish the tools or equipment necessary to do the work.
4. Contractor has the authority to hire and fire employees to perform the work.
5. Contractor will be paid on completion of the project or on the basis of a periodic retainer.

State Agency certification not necessary
I will fill out only the portion which relates to me
per Mr Sawyer February 25, 1992

______________________ Agency Signature ______________________ Date

Independent contractor certifies he/she meets the following standards as required by ORS chapters 316, 656, 657 and 670:

1.** You filed federal and state income tax returns for the business for the previous year, if you performed labor or services as an independent contractor in the previous year. **Washington does not have State Income Tax
I filed Federal Income Tax

2. You represent to the public that you are an independently established business by meeting four (4) or more of the following:

__X__ A. You work primarily at a location separate from your residence, or work primarily in a specific portion of the residence, which portion is set aside as the location of the business.

__X__ B. You have purchased commercial advertising, business cards, or have a trade association membership.

_____ C. You use a telephone listing and service separate from your personal residence listing and service.

_____ D. You perform labor or services only pursuant to written contracts. see below

__X__ E. You perform labor or services for two or more different persons within a period of one year.

__X__ F. You assume financial responsibility for defective workmanship or for service not provided as evidenced by the ownership of performance bond, warranties, errors and omission insurance or liability insurance relating to the labor or services to be provided.

through designers bond and project insurance

Contractor Signature David A. Hoppens Date 2/28/92

Entity DAVID A. HOPPENS

*Corporations are not required to complete this form.

ED:BAM/1-1-92/WPPBAM.2347/1 BAM PSC FORM #50A

written is used where necessary (government agencies have records of transactions)
Private contracts take care of themselves--Payment before progress and the Engineers Lien

A Proposal For

Technical Advice on Mining Rules

Presented to

The State of Oregon Department of Environmental Quality

March 1992

by

David A. Hoppens, PE

DAVID ALAN HOPPENS
STATE OF WASHINGTON
15476
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES: 7-10-92

THE PROJECT TEAM

The company has been operating for a couple of years as a engineering and design organization. Primarily out projects have been run of the call, with the emphasis on environmental and geotechnical concerns. The locality which is home is surrounded by a mineral rich zone which in turn has attracted a host of mining concerns. These concerns all have similar problems which I am sure is universal within the mining industry.

The project team will be made up of myself (David Hoppens) and a administrative assistant. I am a 1970 graduate of Washington State University in Civil Engineering. Received my Professional Engineering License in 1975 and currently licensed to practice in Washington. Professional organizations include: The American Society of Civil Engineers, and the American WaterWorks Association. I am also affiliated with the NorthEastern Washington Geological Society (NEWGS). NEWGS is a group of mining and geological people who have a monthly meeting with prominent guest lecturers. The Organization in based in nearby Republic. My membership could be construed as a potential conflict of interest, but I will assure you that it is only academic. Within the engineering profession a good practice is to keep in touch with closely related professions and organizations. I have a strong interest in geotechnical applications and this is a valuable source of information. My overall experience includes twelve years within the public sector (eight years for the Washington Department of Transportation and four years for Ferry County (County Engineer)). The past ten years has been with the private sector, primarily being self employed with the emphasis of the projects seeming to be within the environmental area. My financial background can best be described with that of necessity. Being a emerging small business in the engineering field places strong demands for the purchasing of: computers, engineering office and field equipment and a large resource database. Due to the high expense of technical equipment the financial background primarily shows one of negative numbers. The firm is primarily composed of myself. I hire people for the specific projects as necessary. The assistants are on call, available here locally, and are highly qualified in their field. Payment usually is as casual labor or contract.

The prime contact person relating to the proposal should be:

☞ David A. Hoppens
POB 130
Malo, WA 99150

(509) 775-3197

Terms like "Canons of Ethics" seem to be forgotten when large sums of money are at stake. I understand fully the reason to question everyone submitting a proposal on their involvement with groups surrounding the mining industry.

During the past five years I have worked for two mining companies (one went bankrupt and I never received my fee), one of which is currently in production. I was a member of the Wilderness Society for two years, I have been a member of Recreation Equipment Inc for 28 years, The NorthEast Washington Geological Society, communicated with Carolyn Brown-Citizens Concerned for Reasonable Mining; Ontario, OR, and have responded to two Environmental Impact Statements concerning proposed mining concerns. Included with some of my major projects also includes involvement in the open-pit gravel crushing operations and land reclamation (one project of which was in a highly scenic, environmentally sensitive area). Some good personal friends of mine are associated directly with the mining industry. I have contacted local mining companies for information relating to engineering design projects which regulators have requested with relation to my projects. Thus the mining concerns in some form or another have contributed to a substantial portion of my income and I have had association with environmental groups.

Obviously the study contractor will interchange dialogue with the mining firms and environmental groups. This is the main purpose of the initial public meeting. As far as an approach to a nonbiased study, the only thing I can say is that I intend to do the study in an engineering fashion or similar to a engineering report, thesis or term paper. All of the input from the mining and other people would be reviewed for relevance to a design or recommendation but no "biased" or other considerations is ever given nor intended to be given. I have never been susceptible to bias, intimidation, coercion, or bribery.

The business probably will not be on your list as a Emerging Small Business, but their is no doubt that it will qualify. I have never worked in Oregon before nor received any pay from any Oregon based firm.

In summation, you can be assured that no bias of whatever form will be shown to any organization. You are my client. The study will proceed under the guidelines of the Scope of the Project with utmost credibility, canons of ethics and engineering professionalism.

PROJECT MANAGEMENT PLAN

The questions to be addressed as a result of the project are lumped into three questions. The questions are: 1. on Liners, Leak Detection, and Leak Collection Systems, 2. on Tailings Treatment to Reduce the Potential for Release of Toxics, and 3. on Closure of the Heap Leach and Tailings Facilities. Upon awarding of the contract for the study the first item would be to proceed with a literature search on the three main topics to be answered. At this time the research, analysis and deciphering of the data for the three objectives would be combined into a typical "project" status. The literature search for the project would include but not be limited to: My personal library, NTIS, EPA, ASCE, American Mining Congress, Northwest Mining association (it is my understanding that they have a rather large library), SME-AIME, US Bureau of Mines, Forest Service, and State Environmental Agencies. The literature search is expected to take seven days. From the search data would be ordered by quick delivery service so that the publications will be available within ten days. During the waiting period for the ordered literature I would review the multitudes of information which is present in my library, plan and attend the Public Meeting requested and begin analyzing the data which is currently available and dissecting it for relevance. Data gathered as a result of the Public Meeting would be reviewed and ordered according to scientific and engineering validity.

About two weeks into the project, the requested data from the literature search arrives. Then for about two weeks I compile and segregate all of the data, do possible computer modeling of systems, and prepare to make the final determinations and recommendations to the Department. It is at this time the project begins to separate into three distinct phases. The phases are a deduction and answer to the three questions posed. The end of this period will mark the thirty day timeframe in the study.

The final two weeks will be used in writing of the draft document and summarizing of the final results.

Communication between myself and the Department of Environmental Quality would be on a very regular basis, even daily if necessary. I would however prefer to report to one person rather than the whole board. The method of communication could be oral telephone usage, FAX, or by letter. My geographic location in not very cooperative with respect to personal contact on a frequent basis.

EXPERIENCE AND CAPABILITIES

A particular project demonstrated complying with **the environmental laws and regulations** would be the recent project in the Methow River. This project was a gravel pit site in a particularly scenic area near Mazama, Washington. The area is undergoing a extreme high rate of development of all magnitudes. My expertise was solicited to design a ultimate reclamation plan for the pit site which may also be used for community recreation purposes as the ownership is 400 acres and the owner will develop. The design was relatively simple, where the challenges came was coordinating my efforts within the Department of Wildlife, Department of Natural Resources, Department of Ecology, Shorelines Management, Okanogan County, The owner, and a local consultant planner who had all of the answers. The planner charged himself with the permitting and politics so I had to coordinate my design independently so as not to interrupt his process. The game department rejected the idea of a input-output open channel proposal because of the anadromous fish and the chance of them becoming lakebound during the dry season. That was however no problem so I pursued my plan and tried not to disrupt any of the processes going on at the planning front. Finally, after the project was basically approved by the Department of Natural Resources, the planner realized that he was a little behind and began getting irritable. After a brief interchange of words suitable for quoting, the planner developed a headache and retired to his office and couch. Seemingly confident that he was correct that I had designed the project the way he wanted and directed me to.

I do not know all of the laws and regulations relating to environmental engineering nor do I want to. There is people who do that for a living. I do frequent myself with the ones which apply to a particular project and usually if a project is engineered somewhat satisfactory the current legal requirements are met.

The **scientific/technical knowledge** probably began twenty-five years or so ago when enrolled as a student having completed the first course in soil mechanics. Since then the experience gleaned from numerous construction and design projects dealing with embankment construction, soil hydraulics, liquidity of soils and hydraulics has contributed to experience. A portion of the liners is earthen, this solicits all of the database in geotechnical applications. Within the past five years I have been involved in three projects with liners. Two of the projects have been associated with the mineral processing industry and the other was discussed with the Town of Republic a month ago as they have a leaky primary sewage lagoon and have to get it fixed very soon.

The Lagoons for the mining concerns were one of earth and one of HDPE, 30 mil. Both projects are very small mining concerns but one must realize that the engineering principals are all the same. The design, installation and repair of the HDPE liners and other liners composed of geomembranes is pretty basic. There are also a thousand salesmen representing manufacturers who will supply you with a multitude of design information, cost data, how superior their product is and why you should use their specifications.

The Town of Republic's project is a little different. The Town had some problems at the time with the consultant and the Administration. Also I guess the problem of new-comers to Republic hit the contractor superintendent and inspector. The problem was booze, women, country music, smalltown, and homegrown. Consequently the facility's second primary cell did not hold water. The project was under recent contract so the Town is looking to a stratified engineered bentonite/soil mix liner all at my recommendation. I feel this will work for this particular application and meet the requirements of the Department of Ecology and the Construction Contract. The Town is currently doing the negotiations with Ecology and they will be the Administrative element. I was in the process of modeling the existing system using the Corps of Engineers Seepage Package (IBM computer application) but much to my chagrin I had a secondary disk death and have not had time to get back to it. Software is available for modelling this system and your systems. I am a little out of order here, but if you want to contact the Town of Republic, their address is: Liz Brown, Mayor; attn: Town Clerk; Town of Republic; PO Box 331; Republic, Wa 99166 (509) 775-3216 and ask for Kelly (Town Clerk).

When first approached about cell designs for the mining industry I could see that I was very deficient in that area. A literature search was undertaken which encompasses literally all phases of liner technology, mineral processing, mine nonpoint drainage, reclamation and closed system design. My library has considerable information in these topics, the majority of which has been read.

The **chemical processing technology** associated with cyanide destruction and reuse will be application engineering taken from the documents which I currently have and those which will be requested during the literature search process. Destruction, recovery, and/or reuse of cyanide is necessary and economical in some applications. My knowledge in this area of process is limited to the six or so publications which delineate it. I have already researched to the extent that availability of additional data is present in the form of papers, transactions, short course proceedings and additional books. Additional data will be researched extensively.

PROJECT EXPERIENCE

The project in Northport, Washington for Matovich Mining and Mountain Minerals was a small project which encompassed: process, reclamation, new source review (air quality permit), the SEPA process, and lined cell design. My role was that of the prime consulting engineer which was responsible for the design of the system. This is a small system rated at about 200 tons per day. The process metallurgy is that of the flotation with cyanide not being used. The primary mineral to be processed is barium sulfate. All Material Safety Data Sheets had to be secured for toxicity and health evaluations. The project was scheduled to go online in September of 1991. I have not heard from the firm so I can only assume they met their startup date. My contact person for the concern is: Al Matovich; PO Box 829; Northport, WA 99157, Al's home phone number is: (604) 367-6621. The best time to catch Al is about 8:00pm and then you are lucky. I have had contact with Greg Flibbert over the project also. Greg is with the Washington Department of Ecology and is in charge of the Air Program. His address is: Greg Flibbert; Washington Department of Ecology; N. 4601 Monroe Suite 100; Spokane, WA 99205-1295. Greg's phone number is: (509) 456-3114. You might also want to talk with Andy Tom. Andy was the engineer which I worked with relating to the hydraulics and tailings cell design. Andy is with the Department of Ecology in Spokane at the same address as Greg's but his phone number is: (509) 456-2875.

For the past five years I have designed assisted in constructed numerous on-site sewage disposal systems in the northeast Washington area. A man who has knowledge of my abilities and ease to work with is George Schlender. George is in charge of the Larger on-site sewage systems for the State of Washington. His address is: George Schlender, RS; State of Washington Department of Health; W. 924 Sinto Avenue L32-4; Spokane, WA 99201 (509) 456-2490. George is really busy, but does have an answering machine. He is really a nice person.

The surface mining reclamation plans which I have designed both for the Mazama Project and for a site near Republic were approved through the Department of Natural Resources for the State of Washington; Box 190; Colville, WA 99114. The person in responsible is Mr Bob Anderson (509) 684-7474. As previously mentioned, the plans were for surface mining operations for aggregate production operations. Hopefully Bob will tell you that my work is satisfactory and acceptable.

RESUME

DAVID A. HOPPENS
POB 130; Malo, Washington 99150-0130
(509) 775-3197

EDUCATION:

Washington State University
BSCE 1970

Numerous Management Seminars
Several Different Sponsors

"Theory Z Management"
Bellevue Community College

Sewage System Design Short Courses
Washington Dept of Health

Civil Engineering--Lectures, Symposiums, PC computer applications and Short Courses

Member: Water Pollution Control Federation, Pacific Northwest Pollution Control Association, American Society of Civil Engineers, American Water Works Association

Registered Professional Engineer (Washington) since August 1975

EXPERIENCE:

Twelve years within the public sector for the Washington State Department of Transportation, and Ferry County (County Engineer). All aspects of civil engineering including design, construction, land surveying, condemnations and management.

Nine years within the private sector as a Civil Engineering Consultant. Projects included: mine milling operations, cell and vault designs, reclamation, onsite sewage treatment and disposal, water systems, structures, geotechnical, materials testing, streets and roads, industrial waste treatment, air pollution control, mapping, planned developments, forensic, acid mine drainage, human factors, cold regions, open channel, pipeline, river hydraulics and a dam project. I also serve on the County's Hazardous Waste Advisory Committee, the Solid Waste Advisory Committee, and a member of a local lake protection/restoration group. Personal Computer experience includes: wordprocessing, spreadsheet, civil and environmental engineering applications (HEC 1&2, HECWRC, OAQPS Air Models, Corps WES and CRREL Programs, KYPIPE, PCSTABL5M, ect), AutoCad, and Fortran. Online services frequented include: CompuServe, OAQPS, PPIE, WTIE, New Source Review, Econet, ect. I attack all of my projects, both typical and nontypical very aggressively in order to minimize the duration of time for design. This gets the design in the hands of the client quickly, before he has time to even begin thinking "where is the plan". My library is very extensive in books, published papers, software and manufacturers literature. I study and frequent myself with new and developing technology. Professional contacts are nationwide.

New and exciting challenges I yearn for.

PROJECT BUDGET

Hours Breakdown-myself

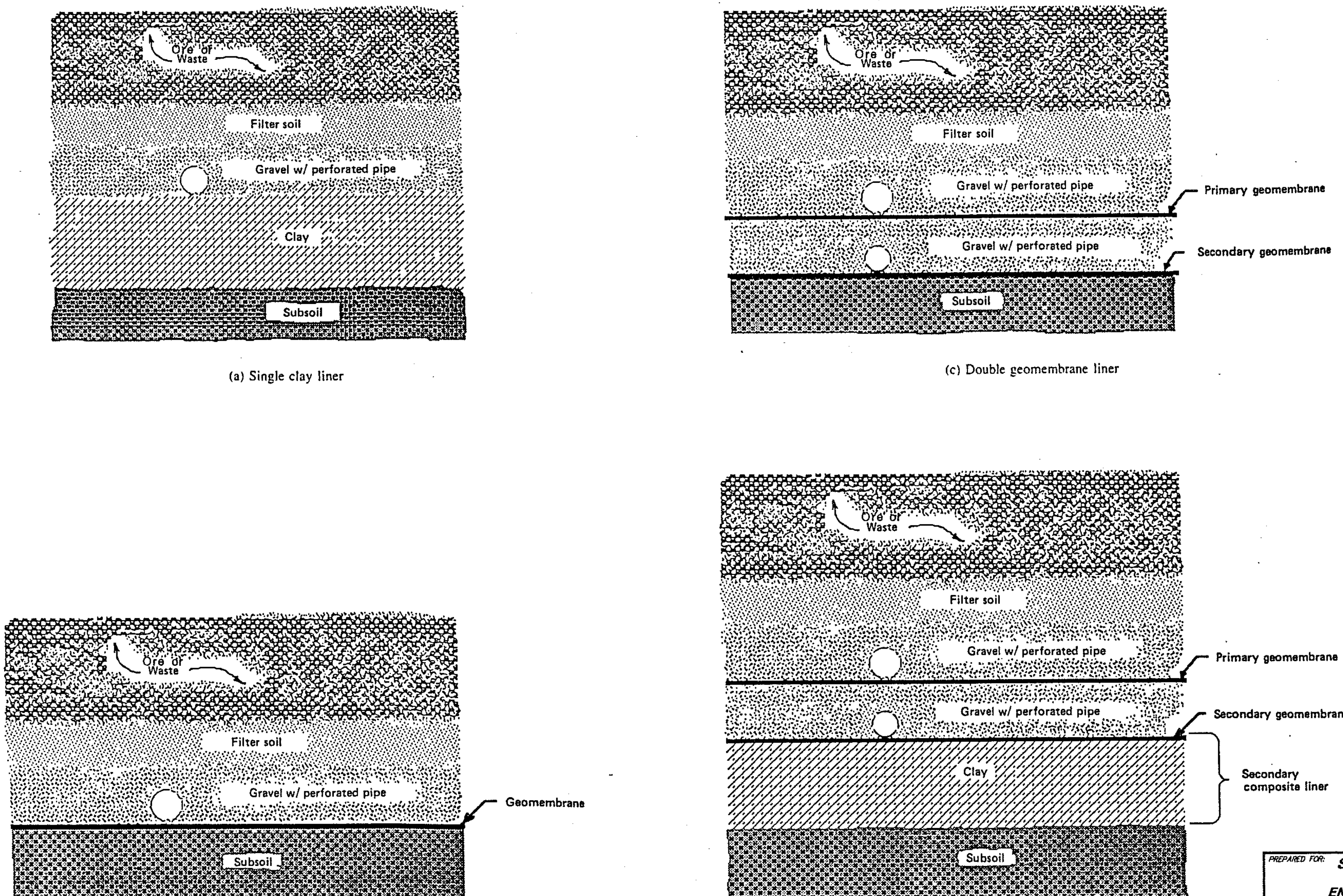
Liners	75
Tailing Treatment	75
Closure	80
Public Meeting	20
Written Report	125
TOTAL HOURS	**375**

support hours--100

Cost Summary

Total Engr. Hrs @ $25.00	$9,375
Total Support Hrs. @ $15.00	$1,500
Total Direct Labor	$10,875
Overhead (117%)	$12,723
Subtotal	$23,598
Travel	$1,200
Reproduction	$1,000
Document Purchases	$2,000
Subtotal	$27,798
Profit (10%)	$2779
GRAND TOTAL	**$30,577.**

In summation I would again thank you for allowing me to participate in the consultant selection process. If selected I will look forward to working with you and the citizens of Oregon. My devotion to the project will be 110% and it will be completed in a technical, timely and professional manner.



(a) Single clay liner

(c) Double geomembrane liner

(b) Single geomembrane liner

(d) Single geomembrane, single composite liner

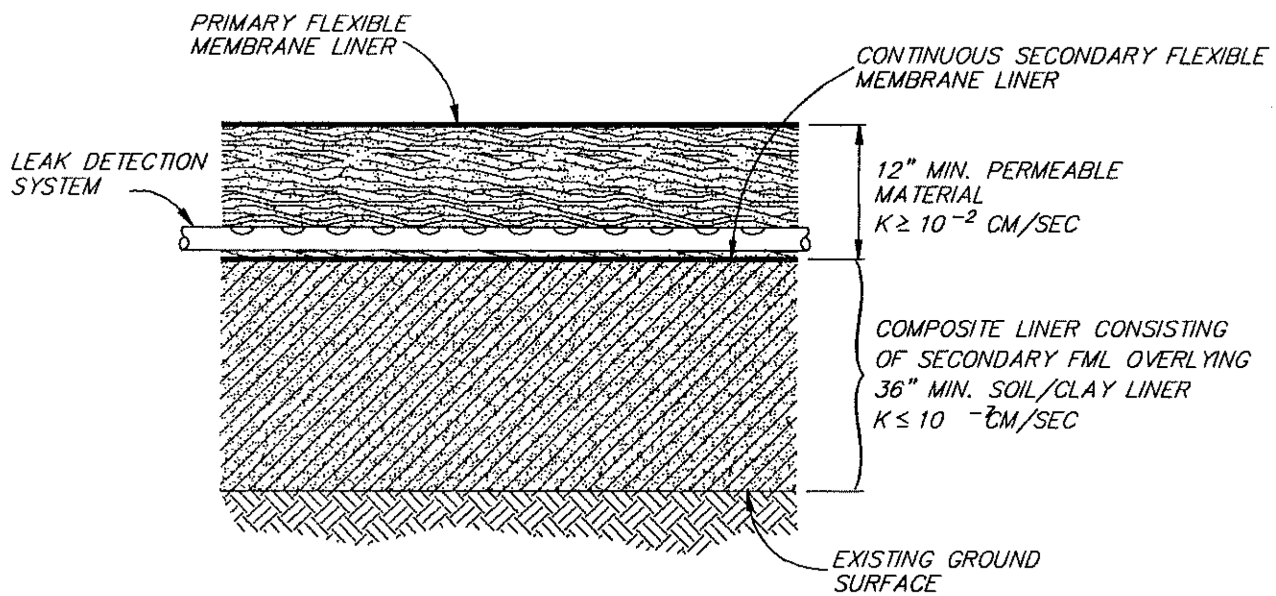
PREPARED FOR: **STATE OF OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY**

PREPARED BY: TRC Environmental Consultants, Inc.

COMBINATION LINER SYSTEMS

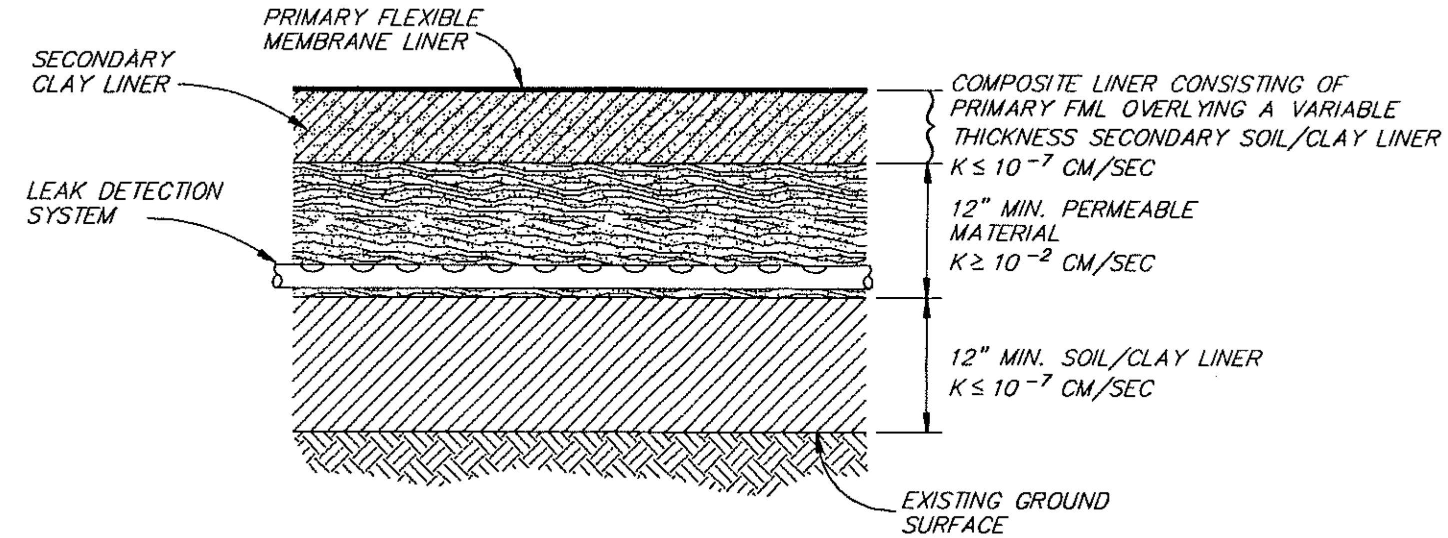
FIGURE 2-7 (a)

323561



a) PROPOSED RULE 340-43-065(A)
LEACH PAD LINER

(NOT TO SCALE)



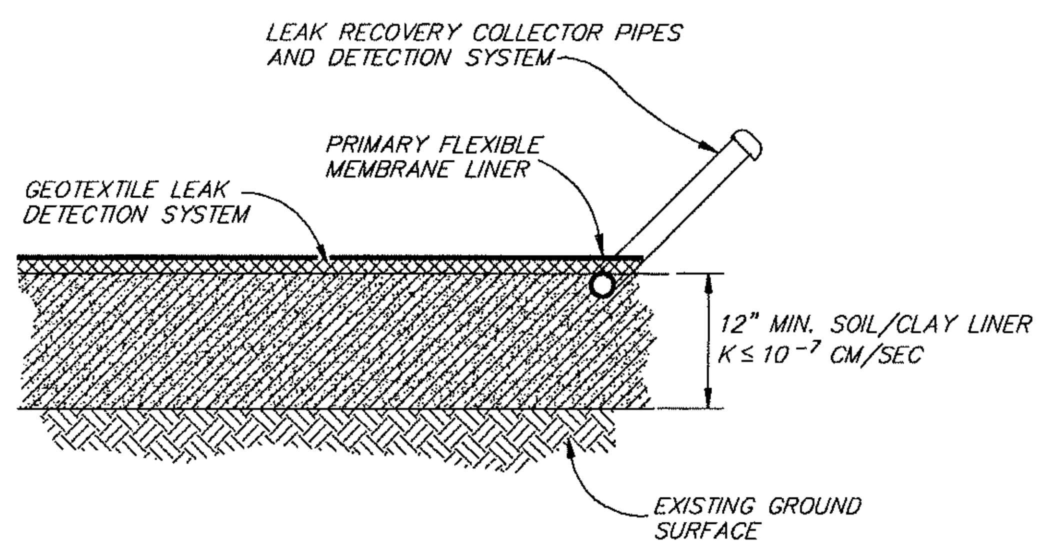
NOTES

1) GEODRAIN (OR EQUIVALENT) MAY BE SUBSTITUTED FOR PERMEABLE MATERIAL DRAINAGE LAYER, WHERE CONDITIONS ALLOW.

2) PREFABRICATED FML/BENTONITE CLAY COMPOSITE SUBLINER MAY BE SUBSTITUTED FOR THE COMPOSITE PRIMARY FML OVERLYING VARIABLE THICKNESS OF CLAY, WHERE CONDITIONS ALLOW.

c) ALTERNATIVE CANDIDATE LINER SYSTEM

(NOT TO SCALE)



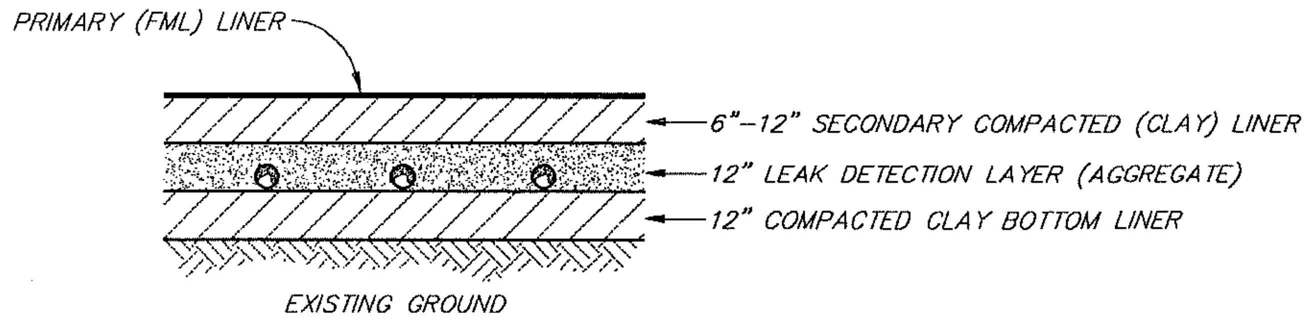
b) PROPOSED DOUBLE LINER SYSTEM

(NOT TO SCALE)

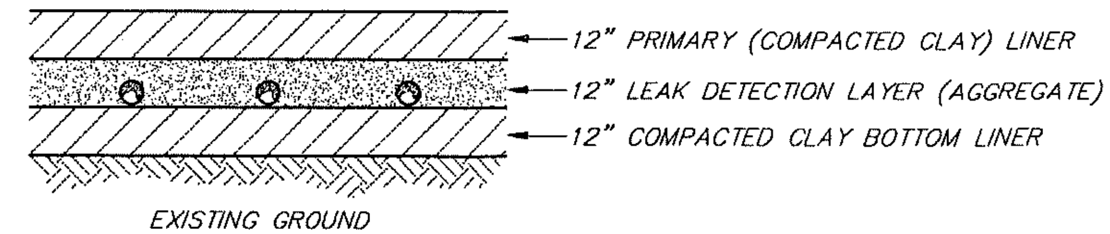
PREPARED FOR: **STATE OF OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY**

PREPARED BY: **TRC Environmental Consultants, Inc.**

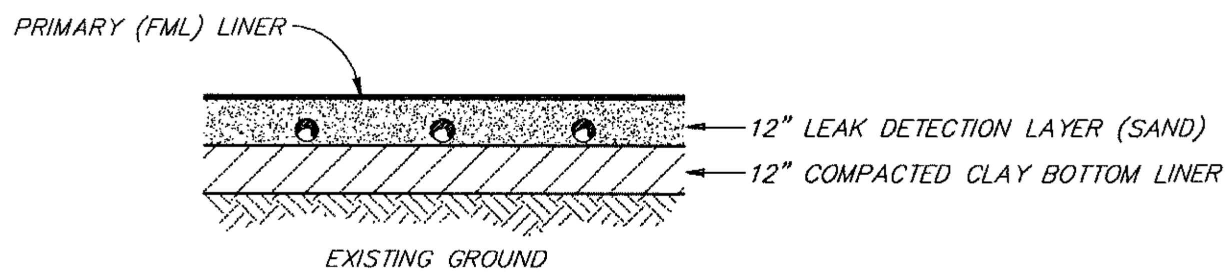
LINER SYSTEMS EVALUATED	FIGURE 2-1



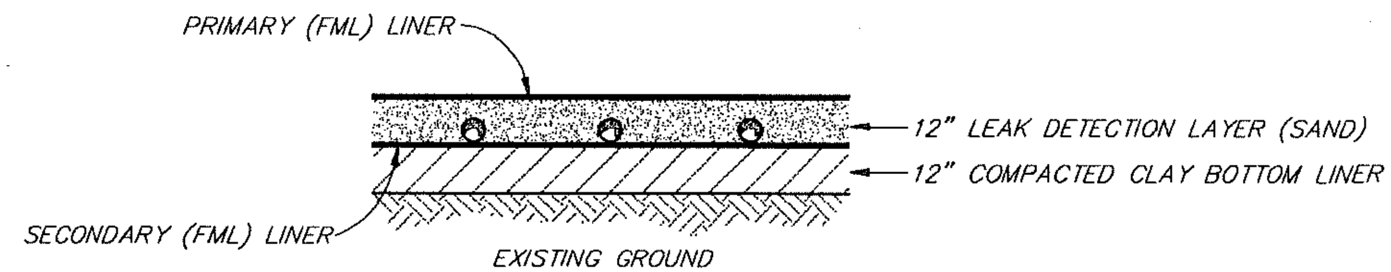
COMPOSITE/CLAY LINER SYSTEM
(NOT TO SCALE)



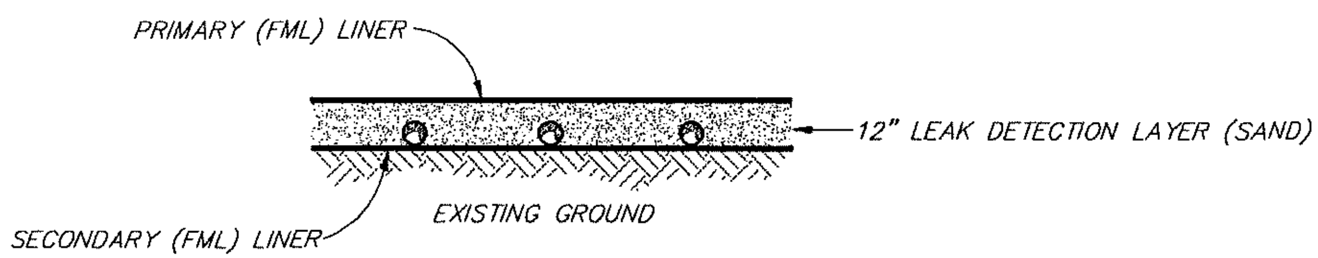
CLAY/CLAY LINER SYSTEM
(NOT TO SCALE)



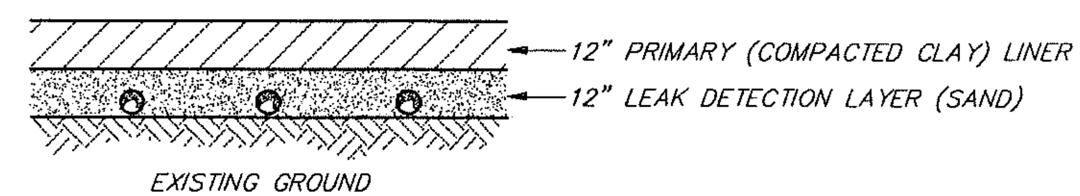
SYNTHETIC/CLAY LINER SYSTEM
(NOT TO SCALE)



FML/COMPOSITE LINER SYSTEM
(NOT TO SCALE)



SYNTHETIC/SYNTHETIC LINER SYSTEM
(NOT TO SCALE)

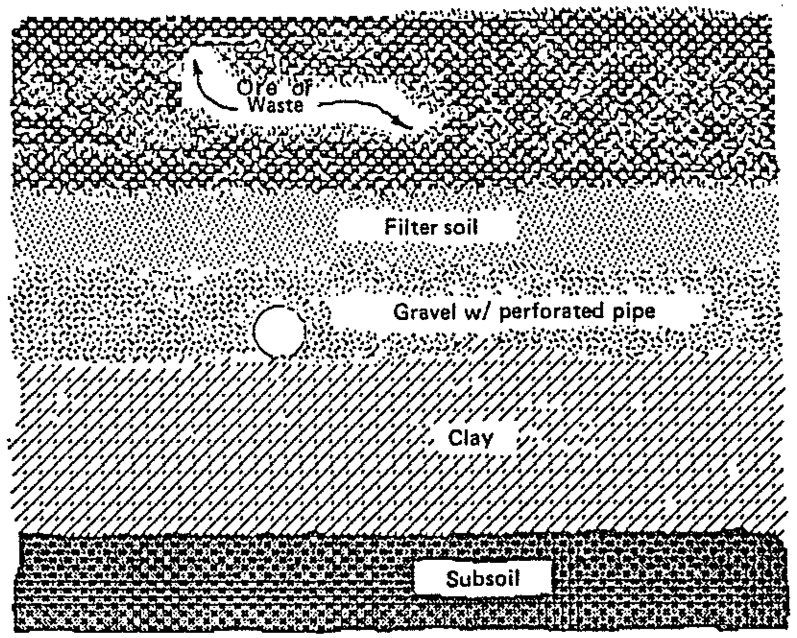


CLAY/SYNTHETIC LINER SYSTEM
(NOT TO SCALE)

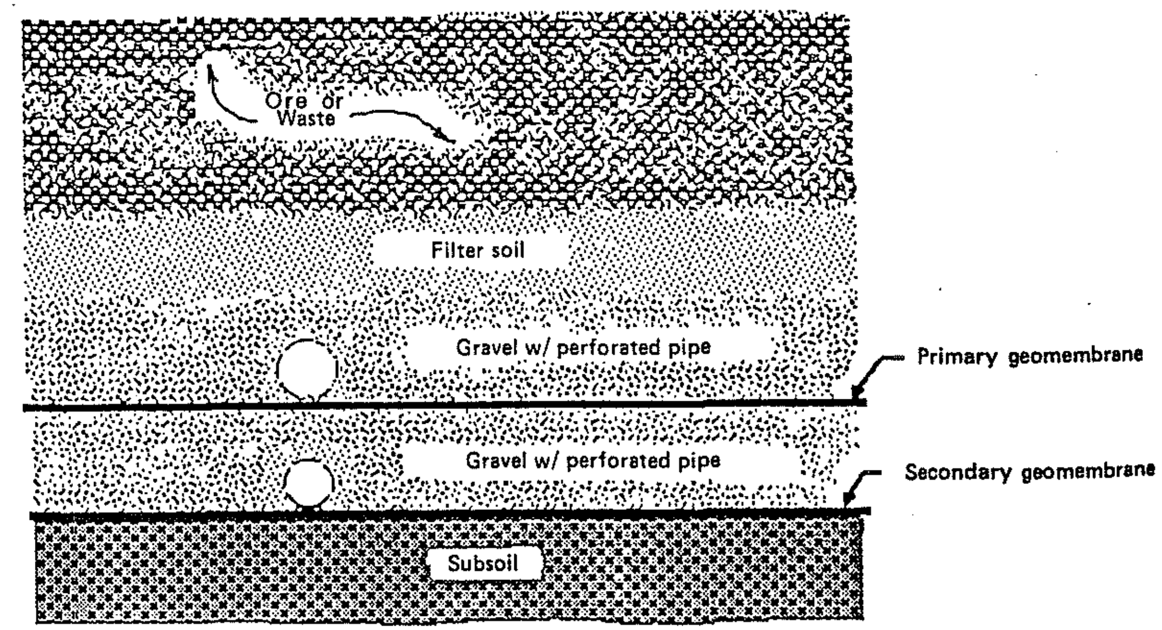
PREPARED FOR: **STATE OF OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY**

PREPARED BY: **TRC Environmental Consultants, Inc.**

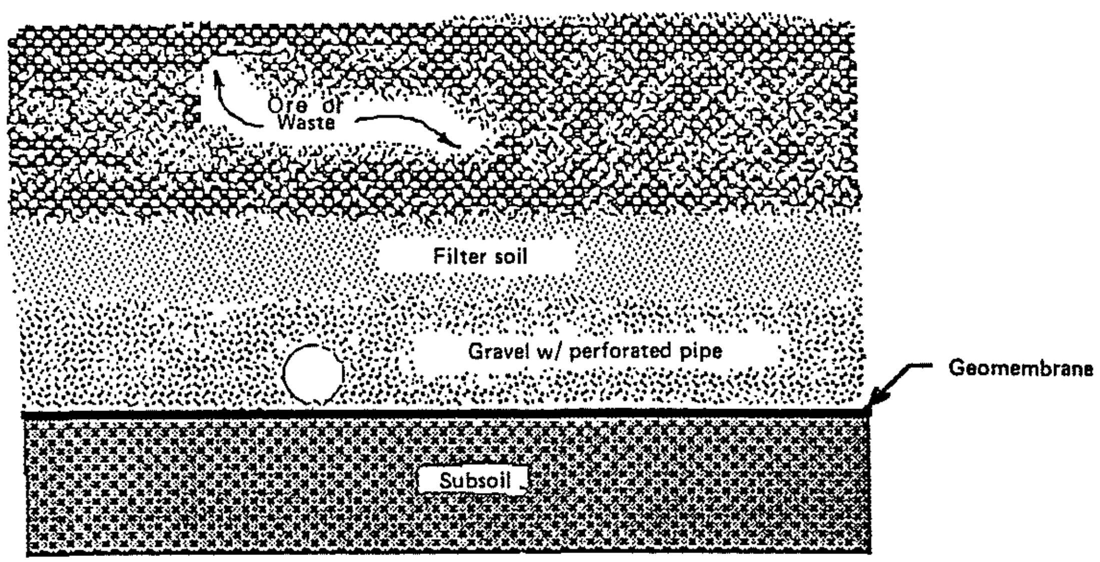
LINER SYSTEMS POTENTIALLY CAPABLE OF MEETING EQC POLICY REQUIREMENTS	**FIGURE** 2-8



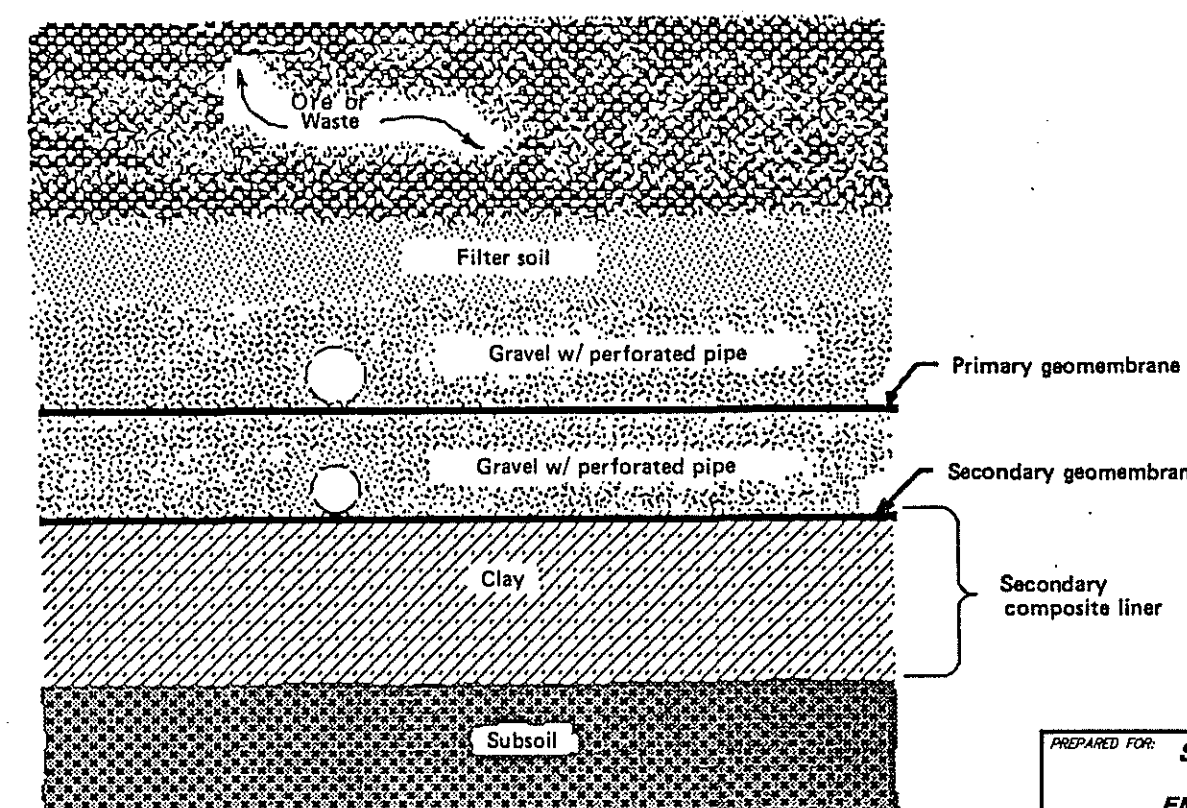
(a) Single clay liner



(c) Double geomembrane liner



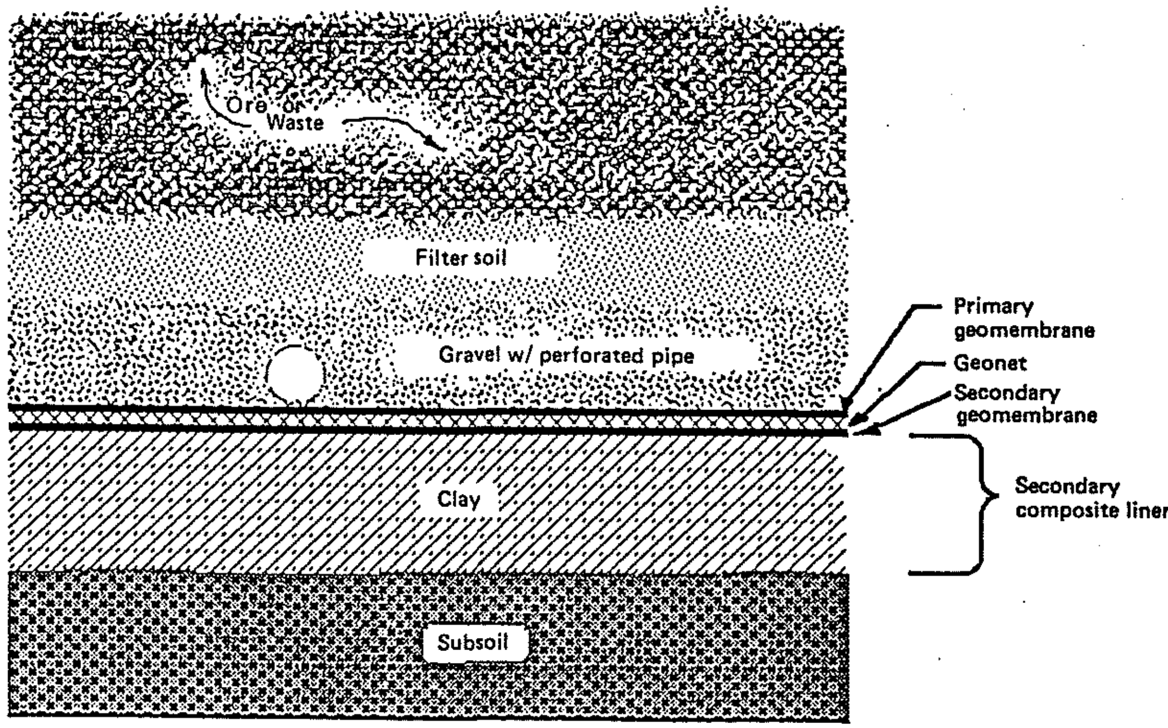
(b) Single geomembrane liner



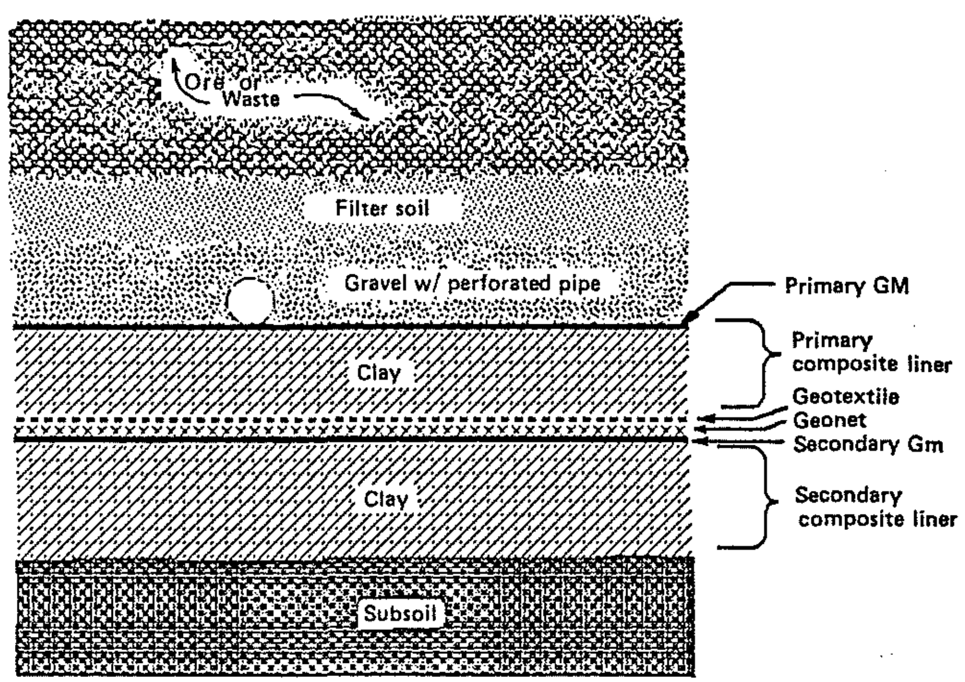
(d) Single geomembrane, single composite liner

PREPARED FOR: **STATE OF OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY**	
PREPARED BY: TRC **TRC Environmental Consultants, Inc.**	
COMBINATION LINER SYSTEMS	FIGURE 2-7 (a)

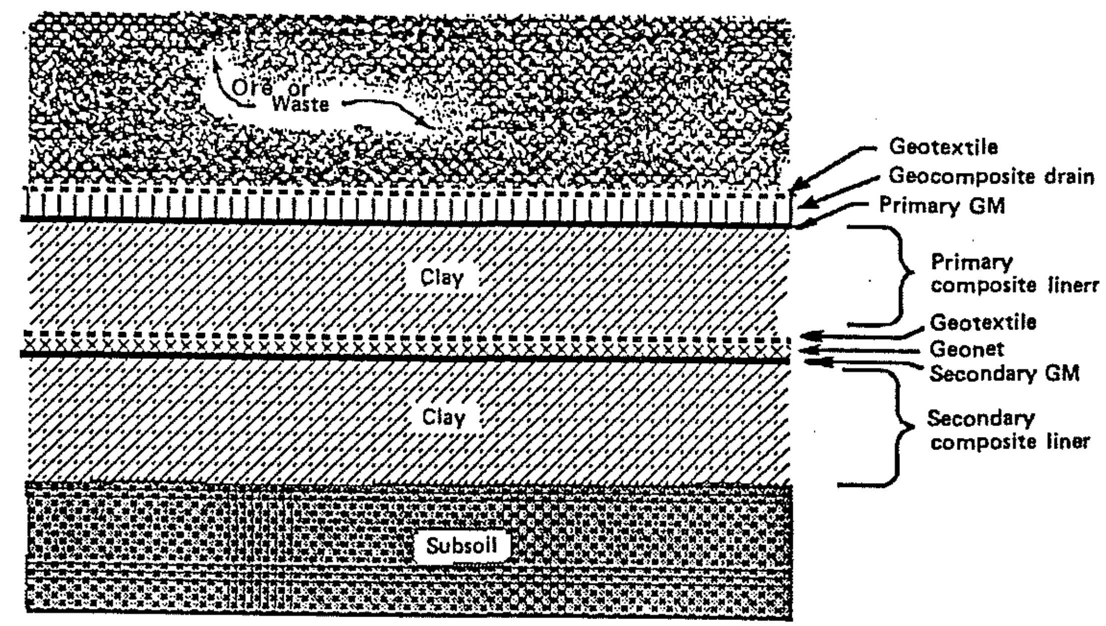
323561



(e) Single geomembrane, single composite liner with geonet



(f) Double composite liner with geonet



(g) Double composite liner with geonet and geocomposite

PREPARED FOR: STATE OF OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY	
PREPARED BY: TRC Environmental Consultants, Inc.	
COMBINATION LINER SYSTEMS (Continued)	FIGURE 2-7 (b)

323561

TABLE 2-2
Level of Certainty Evaluation (Equal Weighting)

LINER SYSTEM COMPONENT	RULE 340 TRIPLE-LINER SYSTEM	PROPOSED DOUBLE-LINER SYSTEM	ALTERNATIVE CANDIDATE LINER SYSTEM	WEIGHT FACTORS
OPERATIONS/MAINTENANCE/REPAIRS CHARACTERISTICS				
Primary Liner	2.00	3.00	4.00	1.00
Leachate Detection and Collection System	4.00	1.00	4.00	1.00
Secondary Liner System	4.00	1.00	2.00	1.00
Category Weighted Score	10.00	5.00	10.00	
PERFORMANCE CHARACTERISTICS				
Primary Liner	2.00	3.00	4.00	1.00
Leachate Detection and Collection Sys-tem	4.00	1.00	4.00	1.00
Secondary Liner Sys-tem	4.00	2.00	2.00	1.00
Category Weighted Score	10.00	6.00	10.00	
FEASIBILITY OF CONSTRUCTION				
Primary Liner	2.00	3.00	3.00	1.00
Leachate Detection and Collection Sys-tem	3.00	2.00	3.00	1.00
Secondary Liner Sys-tem	3.00	3.00	3.00	1.00
Category Weighted Score	8.00	8.00	9.00	
Total Weighted Score	28.00	19.00	29.00	

TABLE 2-3
Level of Certainty Evaluation (Incremental Descending Weighting)
(e.g. Greater Emphasis on Upper System Components)

LINER SYSTEM COMPONENT	RULE 340 TRIPLE-LINER SYSTEM	PROPOSED DOUBLE-LINER SYSTEM	ALTERNATIVE CANDIDATE LINER SYSTEM	WEIGHT FACTORS
OPERATIONS/MAINTENANCE/REPAIRS CHARACTERISTICS				
Primary Liner	2.00	3.00	4.00	3.00
Leachate Detection and Collection System	4.00	1.00	4.00	2.00
Secondary Liner Sys-tem	4.00	1.00	2.00	1.00
Category Weighted Score	18.00	12.00	22.00	
PERFORMANCE CHARACTERISTICS				
Primary Liner	2.00	3.00	4.00	3.00
Leachate Detection and Collection System	4.00	1.00	4.00	2.00
Secondary Liner Sys-tem	4.00	2.00	2.00	1.00
Category Weighted Score	18.00	13.00	22.00	
FEASIBILITY OF CONSTRUCTION				
Primary Liner	2.00	3.00	3.00	3.00
Leachate Detection and Collection System	3.00	2.00	3.00	2.00
Secondary Liner Sys-tem	3.00	3.00	3.00	1.00
Category Weighted Score	15.00	16.00	18.00	
Total Weighted Score	51.00	41.00	62.00	

TABLE 2-4
Level of Certainty Evaluation (Incremental Ascending Weighting)
(e.g., Greater Emphasis on Lower System Components)

LINER SYSTEM COMPONENT	RULE 340 TRIPLE-LINER SYSTEM	PROPOSED DOUBLE-LINER SYSTEM	ALTERNATIVE CANDIDATE LINER SYSTEM	WEIGHT FACTORS
OPERATIONS/MAINTENANCE/REPAIRS CHARACTERISTICS				
Primary Liner	2.00	3.00	4.00	1.00
Leachate Detection and Collection System	4.00	1.00	4.00	2.00
Secondary Liner Sys-tem	4.00	1.00	2.00	3.00
Category Weighted Score	22.00	8.00	18.00	
PERFORMANCE CHARACTERISTICS				
Primary Liner	2.00	3.00	4.00	1.00
Leachate Detection and Collection System	4.00	1.00	4.00	2.00
Secondary Liner Sys-tem	4.00	2.00	2.00	3.00
Category Weighted Score	22.00	11.00	18.00	
FEASIBILITY OF CONSTRUCTION				
Primary Liner	2.00	3.00	3.00	1.00
Leachate Detection and Collection System	3.00	2.00	3.00	2.00
Secondary Liner Sys-tem	3.00	3.00	3.00	3.00
Category Weighted Score	17.00	16.00	18.00	
Total Weighted Score	61.00	35.00	54.00	

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REPORT OF FINDINGS ON
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* * * * * * * * * * * * * * * * * * *

STATE OF OREGON
PROPOSED CHEMICAL MINING RULES

PREPARED UNDER AUTHORIZATION
ODEQ CONTRACT NO. 71-92

State of Oregon
DEPARTMENT OF ENVIRONMENTAL QUALITY
RECEIVED
JUL 22 1992

OFFICE OF THE DIRECTOR

PREPARED FOR:

State of Oregon
Department of Environmental Quality
Portland, Oregon

PREPARED BY:

TRC Environmental Consultants, Inc.
Englewood, Colorado

Project No. 11958-Q82

July 21, 1992

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A TRC Company

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APPENDICES

1.0 INTRODUCTION

1.1 Overview

TRC Environmental Consultants, Inc. (TRC) was retained by the State of Oregon Department of Environmental Quality (ODEQ) to provide an independent evaluation of and advice on specific technical questions relating to proposed rule-making documents pertaining to impending regulation of chemical mining activities. TRC's designated assignment, reflecting the title of this document, was clearly defined with regard to provision of Technical Advice on Chemical Mining Rules, as limited to addressing pertinent rule excerpts and affected parties' concerns as described in the February 7, 1992 Request for Proposal (RFP) document, as prepared and distributed by ODEQ.

Based on information provided in the RFP, it is TRC's understanding that the State of Oregon, Environmental Quality Commission (Commission) is considering adoption of rules to require mining operations using cyanide or other toxic chemicals to protect soils, groundwater, surface waters, and wildlife from contamination or harm by process solutions and waste waters. The protective measures required by the proposed rules include triple liner systems, cyanide recovery and re-use, and chemical detoxification and engineered cover systems for facility closure.

During regulatory development and drafting of the proposed Oregon Administrative Rules Chapter 340 - Division 43 - "Chemical Mining", the public participation process, as required by law, has resulted in identification of a number of concerns (related to technical issues) from various parties to the process. Mining companies and mining trade associations have argued that some of the requirements are unnecessarily stringent, unproven or unavailable. Conversely, environmental protection organizations have argued that the proposed rules may not be adequately protective in certain respects. Extensive debate on these and related policy issues within the Commission and ODEQ has culminated in this review process, wherein TRC has been asked to address in detail the identified technical issues.

The review process was initiated through a May 5, 1992 public meeting wherein ODEQ presented discussion of the policy and intent under which the review would be conducted; TRC presented discussion of corporate qualifications, project team qualifications, disclosure and clarification of potential conflicts of interest, and its technical approach to conducting the evaluation and review. Interested parties were given an opportunity to pose questions on policy (to ODEQ representatives) and on the technical approach (to TRC).

Although numerous technical professionals and/or firms were offered as points of contact by parties interested in the outcome of the evaluation and review, TRC elected to limit direct inquiries (to these designated individuals and/or firms) to those instances requiring specific information beyond that readily available in the literature, so as to eliminate perceived or actual appearance of influence in the process. Only in those cases requiring direct inquiry (such as proprietary cyanide detoxification process technologies, etc.) was such a method employed. Numerous professional papers, texts and treatises prepared by those technical professionals were accessed as part of the data gathering process, as were applicable technical guidance documents as prepared by the U.S. EPA and/or various states (as deemed by TRC to be representative of appropriate state mining regulatory programs for operations similar in scope and/or magnitude to those which the Commission desires to regulate, e.g., chemical mining). A complete record of all references is provided in Appendix A-1 of the document.

To commence technical review, TRC project team members reviewed the record of the rulemaking in ODEQ's offices and were provided copies (as requested by TRC) of relevant documents. In addition, TRC received a document (delivered to the attention of Mr. Harold Sawyer and subsequently forwarded) prepared on behalf of the Oregon Mining Council (by CH2M Hill and Stoel Rives Boley Jones & Grey), entitled "Issue Paper on ODEQ's Proposed Chemical Mining Rules". In addition, a listing of reference materials was provided by The Wilderness Society; all of which were incorporated into this study. An indicated additional list was to have been presented as provided by the Mineral Policy Center, however, that addendum was not received by TRC. As such, TRC initiated direct contact with the Mineral Policy Center (both Washington D.C. and the Bozeman, Montana field office) to obtain certain materials deemed by the Mineral Policy Center to be pertinent technical discussions of the issues of concern. TRC did not at any time attempt to establish contact or receive direct contact from any of the identified concerned parties, inclusive of the Oregon Mining Council, the Northwest Mining Association, Atlas Minerals Company, or the Wilderness Society. Communications from all factions were as a matter of policy directed through Mr. Harold Sawyer. A complete record of all contacts is provided in Appendix A-2. A brief outline of the qualifications of each individual member of the TRC project team participating in the compilation of this report is provided in Appendix A-3.

The contract provided for TRC to prepare a draft report for submittal to ODEQ, with ultimate distribution to identified concerned parties for review and comment. Concerned parties were then allotted seven (7) days for review and comments were delivered directly to ODEQ. Based on review of the draft report, and individual comment letters ODEQ issued a letter response to TRC, along with copies of all comments received from concerned parties.

Based on the ODEQ letter response (dated July 2, 1992), TRC was directed to make certain deletions pertaining to summarization of findings (which were designated by ODEQ as inappropriate and out of scope) and to incorporate, to the extent deemed appropriate by TRC, certain comments regarding clarifications and/or revisions to the draft report text, inclusive of those submitted by concerned parties.

TRC has compiled a comment/response section for integration into the final report, which is provided as Appendix B-1. In that section, TRC has assembled individual comments extracted verbatim from the July 2, 1991 ODEQ letter. Each comment is then responded to, as appropriate. For instance, where ODEQ identified technical errors or misstatements within the text, TRC has acknowledged the comment and amended the text accordingly. The overall result of the process is a final report that addresses all requests and incorporates all directives issued by ODEQ. For ready reference, TRC has also appended unabridged versions of the ODEQ Request for Proposal and Proposed Rule Draft in Appendices C-1 and C-2, respectively.

It is important to note that, due to the structuring of the RFP, each issue was addressed in a stand-alone manner; no provision within the scope of work (RFP) was allowed for evaluation of the cumulative impact, or redundancies effected by application of all proposed rule measures at a single facility. However, it is of utmost importance that the reader fully understand that TRC's findings would differ significantly if such cumulative impacts were assessed (for example, if a liner system is accepted as capable of achieving stated Commission policy for preventing release to the environment, the proposed follow-on measures (cyanide removal and reuse, and hazardous waste type covers) provide little, if any, material reduction in the potential for release (other than an overall reduction in volume consumed over the project duration) of toxic chemicals or metals. To take it one step further, it is even more apparent to TRC that if a policy-achieving liner is employed in conjunction with detoxification, there is an even lesser material reduction to be achieved by additionally covering the detoxified waste.

Conversely, TRC recognizes, and has emphasized, that site-specific circumstances may, in some instances, warrant application of all prescriptive measures. However, this would generally be the exception, rather than the rule.

1.2 Record of Findings

TRC has conducted extensive research and evaluation into the various proposed regulatory components, individually and collectively, while striving to remain within the bounds of "technical evaluation", and while doing so, not entering into areas perceived by TRC or parties to this effort, as representative of "policy evaluation". While TRC has attempted to provide a concise declaration of findings in this section, it cannot be over-stated that the supporting discussion and review presented in Sections 2.0 through 4.0 of this document are critical to the interpretation of the declaration of findings and any subsequent policy decisions forthcoming. The level of detail presented is representative of the complexity of the issues. Likewise, due to the structuring of the RFP, the cumulative result of all proposed rule components, while significant, is not portrayed. However, following are the summarized findings of the evaluation and review of each individual issue.

- **Question 1: WILL EITHER OR BOTH LINER SYSTEMS MEET THE STATED POLICY OBJECTIVE OF THE COMMISSION?**

[The Commission establishes as policy that a liner, leak detection and leak collection system are necessary to assure that any leak will be detected before toxic materials escape from the liner system and are released to the environment. (Note: The Commission considers that the environment begins at the bottom of the last liner.) These systems must assure that if a leak is found, sufficient time is available to allow for the repair of the leak and clean up of any leaked material before there is a release to the environment. Natural conditions, such as depth to groundwater or net rainfall, shall be considered as additional protection but not in lieu of the protection required by the required engineered protection].

NOTE: Three liner systems, as briefly described below, were evaluated for their ability to achieve stated Commission policy:

(1) ODEQ proposed in Rule 340-43-065(4) a heap leach pad liner system consisting of triple liner system consisting of two flexible membrane liners (with 12-inches of permeable material containing a leak detection system between the liners) overlying a 36-inch thick low permeability soil/clay liner.

(2) A double-liner system with between liner leak detection was identified in the Request for Proposal as having been proposed by the Oregon Mining Council. A flexible membrane liner is utilized as the primary liner, overlying a geotextile leak detection layer in direct contact with an underlying low permeability, 12-inch thick, soil/clay liner.

(3) TRC also evaluated a wide range of alternative liner systems, and elected to put forward a design based upon use of a composite primary liner consisting of a flexible membrane liner (FML) over a variable thickness clay subliner, overlying a 12-inch layer of permeable materials (or engineered equivalent) containing a leak detection system, which in turn overlies a 12-inch layer of low permeability soil/clay material. The design employs geotextile materials for liner reinforcement, as appropriate. While this design configuration is not intended to represent the sole recommended design alternative, it does represent one potential (or reasonable variant thereof) alternative capable of achieving stated Commission policy.

Method to Answer or Address Question:

(1) Are each of the various liner systems proposed technically feasible?

- The OAR 340-43-065(4) Triple Liner System is technically feasible.
- The OMC Double Liner System is technically feasible.
- The Alternative Candidate Liner System is technically feasible.

(2) Will each of the various liner systems meet the stated Commission Policy?

- The OAR 340-43-065(4) Triple Liner System will generally meet the stated Commission Policy.

- The OMC Double Liner System will have difficulty meeting the stated Commission Policy.

- The Alternative Candidate Liner System will meet the stated Commission Policy.

(3) For those liner systems which will meet the stated Commission policy, what level of certainty for achieving this policy do you assign to each system?

- Using assigned values (refer to Section 2.3 for discussion), mathematically generated weighted average levels of certainty (the greater the number, the higher the level of certainty) are as follows:

Liner System	*Equal Weight on All Components*	*Emphasis on Lower Components*	*Emphasis on Upper Components*
OAR 340 Triple Liner	28.0	51.0	61.0
OMC Double Liner	19.0	41.0	35.0
Alternative Candidate Triple Liner	29.0	62.0	54.0

(4) Are there other liner systems which will achieve this policy and what level of certainty for achieving this policy do you assign to each?

- There are a number of other liner systems which will achieve this policy. TRC selected one (the Alternative Candidate Triple Liner) for additional analysis, the results of which are presented above.

- There are a number of variations on the permeable zone component of the Alternative Candidate Triple Liner System (as well as for the OAR 340 system permeable zone) that can also achieve this policy with equivalent levels of certainty while offering varying cost advantages (based on the simple comparison of typical costs for installation) over the proposed Alternative Candidate Liner System. The presented Alternative Candidate Liner System design purposefully incorporated certain components equivalent to those in the OAR 340-43-065(4) system, however, alternative engineered geodrain materials for those components have been identified and evaluated as capable of performing at an equivalent level of certainty.

Question 2: DO THE REQUIREMENTS FOR REMOVAL AND REUSE OF CYANIDE MATERIALLY REDUCE TOXICITY AND POTENTIAL FOR LONG-TERM CYANIDE AND TOXIC METALS RELEASE FROM MILL TAILINGS?

[The Commission establishes as policy that the toxicity and potential for long-term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment.]

NOTE: ODEQ proposed in Rule 340-43-070(1) that mill tailings shall be treated by cyanide removal and reuse prior to disposal. Additional treatment shall be also be used, if necessary, to reduce the weak acid dissociable (WAD) cyanide content in the liquid fraction of the tailings to 30 parts per million (ppm), or less.

Method to Answer or Address Question:

(1) Are removal and reuse technically feasible?

- Removal and reuse are technically feasible, but limit the operator to technologies with limitations on operating efficiency.

- The process has been demonstrated in practical application, for example, at the Golden Cross Mine in New Zealand, operated by Cyprus Gold Company, as well as at the DeLamar (silver) Mine in Idaho, operated by NERCO Minerals.

- Engineering firms are available to design and oversee construction.

- Materials and equipment are available to construct.

(2) **Do removal and reuse (evaluated separately) materially reduce the toxicity and potential for long-term cyanide and toxic metals release from mill tailings?**

- Removal of cyanide from tailings <u>does</u> materially <u>reduce</u> the <u>cyanide toxicity</u> and potential for long-term release. Cyanide removal <u>may</u>, dependent on the specific tailings chemistry, <u>contribute to a reduction</u> in toxicity and potential for release of <u>toxic metals</u> over the long-term.

- Reuse of cyanide <u>does not</u> reduce the <u>cyanide toxicity</u> or potential for long-term cyanide and toxic metals release from mill tailings. It does reduce the total quantity of cyanide reagent consumed over the life of the operation. There is a material reduction in operating efficiency when cyanide reuse is employed, in comparison to chemical destruction techniques, particularly at lower concentrations of cyanide in process solutions.

(3) **What is the level of certainty you give to the answers provided above?**

- The generic level of certainty that <u>removal and reuse</u> are technically feasible is high, however, removal and reuse limits the available technology that can be applied to either solid/liquid separation or AVR (acidification/volatilization/reneutralization) processes, which may not provide maximum removal under many tailing chemistry conditions.

- The level of certainty that removal of cyanide materially reduces the toxicity and potential for long-term cyanide release from mill tailings is high.

- The level of certainty that removal of cyanide materially reduces the toxicity and potential for long-term toxic metals release from mill tailings is variable, again dependent upon the specific tailings chemistry.

- The level of certainty that reuse of cyanide materially reduces the toxicity and potential for long-term cyanide release from mill tailings is nil. Reuse does not in any way contribute to a reduction of "toxicity" or potential for release of solutions released to tailings, as reagent concentration in process solutions ideally remains constant at all times. It simply reduces the quantity of make-up reagent required over the life of the operation.

- The level of certainty that reuse of cyanide materially reduces the toxicity and potential for long-term toxic metals release from mill tailings is nil. Reuse does not in any way impact toxicity or potential for release as reagent concentration in process solutions ideally remains constant at all times. It simply reduces the quantity of make-up reagent required over the life of the operation.

(4) **Are there other tailings treatment technologies which will equally, or more effectively achieve the policy of the Commission?**

- There are a number of tailings treatment technologies which will equally or more effectively achieve the stated policy of the Commission. In addition, these technologies are oftentimes technically more appropriate than removal and reuse under given tailings chemistry, offer significant economic advantage, greater operational flexibility, and result in more efficient utilization of resources. These technologies are discussed in Section 3.1.4

Question 3: **DO THE REQUIREMENTS OF DETOXIFICATION (CYANIDE REMOVAL BY RINSING) OF THE HEAP AND COVERING OF THE HEAP AND TAILINGS FACILITY TO EXCLUDE AIR AND**

WATER MATERIALLY REDUCE THE LIKELIHOOD OF ANY RELEASE TO THE ENVIRONMENT OF TOXIC CHEMICALS AND METALS CONTAINED IN THE HEAP OVER THE LONG TERM?

[Note: The Commission establishes as policy that the closure of the heap leach and tailings disposal facilities will prevent release to the environment of toxic chemicals contained in the facility.]

Method to Answer or Address Question:

(1) **Are detoxification and covering (as prescribed in this rule) technically feasible?**

- Detoxification and covering of heap leach facilities is technically feasible.

- Detoxification and covering of tailings facilities is technically feasible.

(2) **Do detoxification and covering (evaluated separately and together) materially reduce the likelihood of a release of toxic chemicals and metals to the environment?**

<u>Heap Leach Facilities</u>

♦ *Toxic Chemical Release Potential*

- Detoxification of heap leach materials (spent ore) does materially reduce the likelihood of a release of toxic chemicals to the environment.

- Covering of heap leach materials (spent ore) without prior detoxification does not materially reduce the likelihood of a release of toxic chemicals to the environment.

- Covering of decommissioned heap leach facilities, following detoxification of cyanide concentrations within the spent ore, may materially reduce the likelihood of a release of toxic chemicals to the environment in some instances, but this primarily results from the contribution of detoxification. Conversely, covering in addition to detoxification, if applied inappropriately, can adversely affect control of releases of toxic chemicals to the environment.

◆ *Toxic Metal Release Potential*

- Detoxification of heap leach materials (spent ore) does not materially reduce the likelihood of a releae of toxic metals to the environment.

- Covering of heap leach materials (spent ore) without prior detoxification does materially reduce the likelihood of a release of toxic metals to the environment.

- Covering of decommissioned heap leach facilities, following detoxification of cyanide concentrations within the spent ore, where spent ore chemistry dictates (due to acid-generating potential), does materially reduce the likelihood of a release of toxic metals to the environment. However, where acid-generating potential is not a concern, little, if any additional benefit is realized toward materially reducing the likelihood of a release of toxic metals to the environment by covering after detoxification.

Tailings Facilities

◆ *Toxic Chemical Release Potential*

- Detoxification of mill tailings does materially reduce the likelihood of a release of toxic chemicals to the environment.

- Covering of mill tailings without prior detoxification does not materially reduce the likelihood of a release of toxic chemicals to the environment, except in the case of net precipitative buildup.

- Covering of decommissioned tailings facilities, following detoxification of the cyanide concentrations within the tails, in most instances does not materially reduce the likelihood of a release of toxic chemicals to the environment. Conversely, covering may inhibit further reduction of toxic chemicals by natural degradation.

◆ *Toxic Metal Release Potential*

- Detoxification of mill tailings may not materially reduce the likelihood of a release of toxic metals to the environment.

- Covering of mill tailings without prior detoxification may not materially reduce the likelihood of a release of toxic metals to the environment, except in the case of net precipitative buildup.

- Covering of decommissioned tailings facilities, following detoxification of the cyanide concentrations within the tails, in some instances may materially reduce the likelihood of a release of toxic metals to the environment, primarily as a result of reducing the potential for acid generation and resultant mobilization of toxic metals.

(3) **What is the level of certainty you give to the answers provided above?**

- Level of certainty of findings described above is high. Level of certainty with respect to application of findings varies with given site conditions (i.e., in many instances, prescriptive proposed rule requirements may function favorably; likewise, in many instances the prescriptive rule requirements may function with adverse consequences, resulting in non-achievement of Commission policy).

(4) **Are there other technologies which will equally, or more effectively achieve the policy of the Commission?**

- There are variants on the proposed technologies that can equally or more effectively achieve the policy of the Commission. Specific site conditions dictate where variants on detoxification and/or cover requirements are appropriate.

- Specifically, once heap leach or tailing materials are detoxified, typical earthen cover systems can equally or more effectively achieve the policy of the Commission at significant economic advantage over prescriptive composite liner systems designed for "hazardous waste" impoundment cover systems.

TRC was assigned the task of evaluating specific technical aspects of varying environmental protective measures related to chemical mining. This in-depth evaluation has resulted in findings, as described above, that indicate that in many instances, there is no single prescriptive design standard that will achieve the stated Commission policies in all instances. TRC has reported these findings as depicted in the foregoing responses to direct questions; TRC, by recording these findings is in no way making any statement(s) with regard to policy.

Due to the heavy emphasis from the various commentators challenging TRC's finding that there is no single prescriptive design standard that will achieve the stated Commission policies in all instances, TRC (as part of scope of work for each issue, pertaining to the method for response to the question on availability of alternative technologies) conducted further investigation into identification of chemical mining operations that have been recognized by reputable and technically knowledgeable constituencies as exhibiting exemplary operational records and achievements relative to design, operation, and closure.

A prominent representative mine facility identified in this investigation is Coeur d' Alene Mines Thunder Mountain Mine, located adjacent to the Frank Church River of No Return Wilderness Area (Payette National Forest) in central Idaho. This facility was presented the first "Environmental Leadership Award" in October, 1991 [Ref 47]. The Environmental Leadership Award was developed by the DuPont Corporation to recognize those mining companies which "place corporate environmental stewardship fully in line with public desires and expectations". The award selection committee was comprised of members providing a representative cross-section of leading industry, political, and environmental constituencies. In order to assess potential alternatives capable of equally or more effectively achieving Commission Policy, TRC contacted representatives of Coeur d'Alene Mines to determine design and operational configurations employed at the Thunder Mountain Mine. According to Coeur d'Alene Mines, design components of interest included:

- A liner system, consisting of, (from the bottom up): a compacted soil/clay base liner (taking advantage of site specific conditions which offer extensive natural clay deposits underlying the heap leach pad location); an aggregate leak detection and drainage layer consisting of minus 2-inch washed aggregate; an 80 mil HDPE flexible membrane liner, and; a 6-inch sealed asphalt layer. These liner components were then complemented with a sized 18-inch ore layer to facilitate leachate collection, thereby reducing hydraulic head buildup upon the liner system.

- Cyanide detoxification was accomplished through alkaline chlorination rinse cycle applications, ultimately achieving less than 0.2 mg/L free cyanide (and approximately equivalent concentrations of WAD cyanide) as determined through stabilized 2-hour interval testing over a 24-hour period. Detoxified spent ore was then removed from the heap and placed in a waste unit; spreading was utilized to maximize benefits of continued volatilization and ultraviolet degradation. Predetermined volumes of spent tailings have also been utilized in backfilling of selected mine pit areas.

- Cover of the waste units referred to above consisted of, again, advantageous utilization of site-specific conditions by employing a naturally occurring compacted clay base prior to deposition of the spent ore; subsequent placement of a 6-inch compacted clay cover; and ultimately, application of topsoil/growth medium to establish a vegetative cover. Provisions were made for surface water diversion to minimize infiltration and erosion potential.

What TRC has determined from this investigation into alternative technologies capable of equally or more effectively achieving the Commission policy is that the policy can be effectively achieved through alternative design configurations. It is important to note that each aspect examined for this award-winning operation differs substantially from the prescriptive design standards contained within the ODEQ proposed rules for chemical mining. Perhaps more importantly, it can be noted that the successfully engineered design was heavily founded upon maximum utilization of site-specific conditions and attributes. Without the allowance for flexibility in design, many of the site-specific attributes would not have been utilized.

2.0 QUESTIONS ON LINER SYSTEM DESIGN STANDARDS

2.1 Introduction

In this section of the report, TRC has addressed each of the four heap leach pad liner system questions pertaining to evaluation of the following two liner systems: 1) the proposed OAR 340-43-065(4) triple-liner system, and 2) the double liner system (identified in the RFP as being proposed by the Oregon Mining Council). In addition, these questions have been addressed with regard to the evaluation of an "alternative candidate" liner system, selected for possible consideration by the ODEQ. Discussion pertaining to the evaluation of alternative liner system configurations as well as to the selection process for the alternative candidate liner system is presented in Section 2.4 of this report. A description of each of the three heap leach pad liner systems evaluated is provided in the following paragraphs.

TRC notes, for clarification, that the following discussion pertains solely to heap leach pad liner system evaluations. Evaluation of these liner systems for suitability or practicality of use as tailing impoundment liner systems is beyond the scope of the RFP.

The proposed OAR 340-43-065(4) triple-liner system (Figure 2-1A) is comprised of a leak detection piping system (situated in 12 inches of permeable material) between primary and secondary continuous flexible membrane liners (FML's). The permeable material is required to possess a minimum permeability of 10^{-2} cm/sec. A third (bottom) liner consisting of a 36-inch thick layer of low permeability soil/clay materials, possessing a maximum permeability of 10^{-7} cm/sec underlies the top two liners and the leak detection system layer. The leak detection system is to be capable of detecting a leachate leakage rate of 400 gallons per day per acre (gpd/ac), within 10-weeks of leakage initiation.

The double-liner system (Figure 2-1B) is comprised of a primary liner of continuous FML overlying a 12-inch thick soil/clay bottom liner possessing a maximum permeability of 10^{-7} cm/sec. The two liners are proposed to be separated by a geotextile layer to be tied to collector pipes spaced at appropriate intervals used to detect leakage within the prescribed 10-week time period.

The "alternative candidate" liner system (Figure 2-1C) can be considered a triple-liner system (similar to the OAR 340 triple-liner system) or a double-liner with a composite primary component. The liner system selected is comprised of a composite liner system consisting of a primary continuous FML situated directly over a secondary low permeability clay subliner. The composite liner overlies the leak detection system layer, consisting of a 12-inch layer of permeable material possessing a minimum permeability of 10^{-2} cm/sec and containing a leak detection piping system. The underlying bottom clay/soil liner consists of a 12-inch layer of low permeability soil/clay materials, possessing a maximum permeability of 10^{-7} cm/sec. A separate layer of geotextile materials or other cushioning materials is recommended, when necessary, to cushion the composite liner from both the heaped ore material and the permeable material component of the leak detection system layer.

Evaluations of the three liner systems were conducted in order to technically address the four liner system questions posed by the ODEQ. The questions are restated as follows:

Question 1: Is each of the liner systems proposed technically feasible?

Question 2: Will each of the various liner systems meet the stated Commission policy?

Question 3: For those liner systems which meet the stated Commission policy, what level of certainty would be assigned to each system?

Question 4: Are there other liner systems which will achieve this policy and what level of certainty would be assigned to each system?

In addition to the technical evaluation, typical costs associated with the installation of the various liner system configurations have been developed (Section 2.5) for comparative analysis.

The approach for addressing each of the questions was based on TRC's knowledge and expertise, as well as utilization of published information and technical data currently available from sources such as the U.S. EPA, other regulatory agencies and state jurisdictions; the Society of Mining Engineers (SME), the American Society of Civil Engineers (ASCE), the Geosynthetics Research Institute and other reliable sources.

2.1 Technical Review and Evaluation of Liner Systems Feasibility

2.1.1 Introduction

In order to address Question 1, (Are the various liner systems technically feasible?), a technical review and evaluation of the three liner systems was conducted with regard to each system's expected: 1) Performance Characteristics; 2) Operation, Maintenance and Repair Considerations; and 3) Construction Feasibility. Items considered for each of the three evaluation categories, are summarized in the following subsections.

1) <u>Performance Characteristics Considerations</u>

a) Evaluation of the leak detection and collection system's ability to achieve the stated Commission policy.

b) Evaluation of the leak detection system's deterioration potential with regard to various external stimuli, including clogging, effects of surface loadings and environmental considerations.

c) Evaluation of the liner systems with regard to permeability and ability to achieve the stated Commission policy.

d) Evaluation of geotechnical considerations with respect to each liner system, including: ability to withstand typical pad loading activities, strength, stability, sliding and slippage potential, as well as settlement considerations.

e) Evaluation of the liner systems with regard to providing sufficient factors of safety or replication in the design, should distress to the system occur.

f) Evaluation of the liner systems with respect to the leak detection and collection system's ability to be utilized to identify locations of leakage in the primary liner system.

2) Operational, Maintenance, and Repair Considerations

a) Evaluation of the expected ease of operations in carrying out normal maintenance procedures and repair of the liner systems.

b) Evaluation of the liner systems with respect to being expanded or constructed in stages corresponding to ongoing ore loading and pad expansion.

c) Evaluation of each liner system with regard to remedial operations, in the event a leak would occur.

d) Evaluation of decommissioning and long term post closure maintenance considerations which could affect the liner system's long term functionality.

3) Construction Feasibility Considerations

a) Evaluations of Quality Assurance/Quality Control (QA/QC) considerations necessary for successful construction of each liner system.

b) Evaluations of the level of complexity and the potential for problems which may arise due to the limitations and variances in the construction of each liner system.

The technical evaluations for each of the liner systems are presented in the following report subsections. Due to the extensive discussion pertaining to geotextile and related products (which comprise various liner and other components of each liner system) the following glossary is provided.

GLOSSARY

A general discussion of terminology used in the geotextile industry is in order to clarify certain discussions contained within this section. Accepted convention [Ref 6] is as follows:

<u>Geotextile</u> - *Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure or system.*

<u>Geogrid</u> - *A deformed or nondeformed gridlike polymeric material formed by intersecting ribs joined at the junctions used for reinforcement with foundation, soil, rock, earth or any other geotechnical engineering-related material as an integral part of a human-made project structure or system. Geogrids are typically used to enhance stability and/or minimize settlement in structures such as embankments, retaining walls, or foundations constructed upon soft materials.*

<u>Geonet</u> - *A netlike polymeric material formed from intersecting ribs integrally joined at the junctions used for drainage with foundation, soil, rock, earth or any other geotechnical-related material as an integral part of a human-made project, structure, or system. Geonets are typically used for subgrade drainage applications such as under pond or landfill liners or behind retaining walls.*

<u>Geomembrane</u> - *An essentially impermeable membrane used as a liquid or vapor barrier with foundation, soil, rock, earth or any other geotechnical engineering-related materials as an integral part of a human-made project, structure, or system. Geomembranes are typically used as liners, barriers, or pond linings due to their relative impermeability.*

<u>Geocomposite</u> - *A manufactured material using geotextiles, geogrids, geonets, and/or geomembranes in laminated or composite form.*

<u>Geosynthetics</u> - *The generic term for all synthetic materials used in geotechnical engineering applications; it includes geotextiles, geogrids, geonets,*

2.1.2 *Proposed OAR 340-43-065(4) Liner System (hereafter referred to as "OAR 340 Triple Liner System)*

2.1.2.1 Performance Characteristics (OAR 340 Triple-Liner System)

a) Leak Detection System (OAR 340 Triple-Liner System)

The leak detection system as proposed for the OAR 340 triple-liner system (see Figure 1(a)), utilizes a 12-inch layer of permeable material possessing a minimum permeability of 10^{-2} cm/sec in conjunction with a leak detection piping system. The leak detection system is situated between the primary flexible membrane liner (FML) and the secondary FML. The secondary FML is situated directly on a 36-inch thick bottom liner to be constructed of soil/clay materials, possessing a maximum permeability of 10^{-7} cm/sec.

The leak detection system as proposed adequately achieves the stated EQC policy requirements for leak detection and adequacy of time for repair of a leak and clean up of material leakage prior to its release into the environment.

The ability of the leak detection system to detect leakage of toxic solutions to the environment including a leak detection rate of 400 gpd/acre (assuming steady-state conditions) is a function not only of the permeability of the material in which the leak detection piping system is situated, but also, the pipe size, spacing, length of piping and slope of the leak detection system layer. Also of related importance are the locations and distances of the leak detection system monitoring locations from a potential leakage source. Leakage from the primary liner to the detection system for the proposed liner system consists of two types of fluid flow; 1) seepage flow of the leachate from a membrane defect through the permeable material, to the detection piping system and 2) conduit flow of the leachate through the leak detection piping system to the monitoring location. The proposed rule requirement that leakage be detected within a 10-week period after its initiation will require that the leak detection system be designed in conjunction with the particular heap pad site. Factors such as the pad's layout, areal extent and slope, will affect the spacing, diameter and layout of the leak detection piping system, as well as the location of the monitoring points. In order to detect leakage within the specified time period, the seepage and conduit flow velocities must be analyzed for selection of appropriate monitoring locations. It should be noted that the velocity components of leachate flow within the leak detection system will be a function of the pad slope, material permeability, and the leak detection pipe size and layout. It should be noted that the hydraulic head within the leak detection layer would be hydraulically connected to the secondary liner. As such, operational /hydraulic head should be minimized as much as possible to reduce the seepage rate through the secondary liner and to reduce the potential of toxic material release to the environment.

The leak detection system was evaluated with regard to its deterioration potential. Factors related to the flow of leachate through the system have been considered as resulting from leakage through the primary liner, in addition to factors unrelated to leakage.

Damage to the leak detection system can result during the construction of the liner system and/or as a result of operations on the pad, including placing of the ore on the pad. Environmental factors or other natural causes may also contribute to the system's deterioration potential, and are discussed in the following paragraphs.

During construction of the liner system, the leak detection piping system, which commonly consists of perforated flexible corrugated pipe or PVC piping, may be subjected to excessive stresses. This will generally occur if a sufficient depth of cover is not provided above the piping materials, or if excessively heavy equipment is driven over the otherwise adequately covered piping system. In general, the cover materials will provide an arching effect over the piping system, thereby reducing the stresses directly experienced by the piping. Ore placement will also contribute to the stresses experienced by the piping system. Often, however, the greatest stresses experienced by liner system components will be those occurring during the pad's construction, thus emphasizing the importance of construction quality assurance/quality control programs.

Damage to the leak detection piping system may also result from exposure to environmental conditions such as ultraviolet radiation (sunlight), adverse weather conditions, bacteria and fungi, while the materials are being stored or constructed [Ref 1, 2, 3]. Even after the piping materials are installed, they may be subjected to these factors, including heating and cooling cycles, which may in some environments, result in overstress or fatigue of the materials [Ref 3, 4].

During the leak detection system's operation (assuming leakage through the primary liner may be occurring), the system can become clogged with fines, either originating from within the ore or in the permeable drainage material surrounding the pipe [Ref 1, 4]. The fines may clog the permeable drainage material and the perforations of the leak detection piping system, reducing the conveyance capacity of the system. Therefore, the permeable materials should be selected cautiously to avert clogging potential. The allowable fines content present within the material may also be specified as a gradation requirement [Ref 1]. The use of filter fabrics or a filtered gradation specification will also aid in protecting the components of the leak detection system from clogging. Similar requirements may be applicable to the surface leachate collection and recovery system, to reduce its potential for clogging as well as to reduce buildup of leachate (hydraulic) head over the primary liner.

b) Permeability Considerations (OAR 340 Triple-Liner System)

The ability of the proposed liner system to meet the requirements of the Commission policy with respect to permeability was evaluated for each component of the system, including the primary liner, the leak detection system, and the secondary and bottom liners.

The primary liner is to consist of a continuous flexible membrane geosynthetic liner. As a result, the liner should possess a permeability well below the ODEQ proposed 10^{-7} cm/sec., provided the liner is installed properly and in conjunction with a QA/QC program. This permeability should adequately satisfy the Commission requirements, since any leakage through the primary liner will be detected within a short time frame due to the thinness of the FML and the infinitesimal breakthrough time to the leak detection system of any leakage. The resulting permeability of the liner will be a function of the number of liner defects resulting from its installation and operations on the pad. Precautions should be taken, therefore, to minimize the occurrence of pinhole leaks, seam leaks, tears and punctures. Standard practices have shown that the occurrence of such liner defects can be substantially reduced with a properly conducted QA/QC program and operations plan [Refs 1, 4, 5]. Minimizing the number of seams will also help, for example, by utilizing larger width FML materials. In addition, the utilization of geotextiles and/or cushioning materials such as sand, will generally reduce the potential for liner damage from construction operations. Protection of the liner from the overlying ore and the underlying permeable drainage materials may be beneficial, particularly if the materials exhibit sufficient angularity to puncture the primary liner [Ref 4]. Standard puncture resistance tests should be conducted to determine the appropriate stress levels at which puncturing would occur with (and without) the use of protective cushioning or geotextile materials [Ref 6].

The leak detection system's permeable material layer should meet the EQC policy. In general the ODEQ-proposed permeability of 10^{-2} cm/sec will ensure "free draining materials". Materials of this permeability are commonly used to convey greater amounts of flow than could be expected from leakage in a heap leach pad. Such permeable materials are utilized for underdrains in other areas of application of subdrains. In general, the gradation of the permeable material will provide a good indication of the material's permeability, including the amount of fines present within the material. If the permeability of the material is questionable (for example, as a result of the presence of excessive fines or indications that the material has the potential for deterioration) permeability and other appropriate tests should be performed on representative material samples. The presence of fines in the material, may give rise to the potential for self-clogging of the material and the clogging of the perforations of the leak detection piping system. If the potential for clogging exists, appropriate measures should be taken such as the development of a gradation or filter criteria, or utilization of filter fabrics [Ref 1].

The secondary (or middle) liner, like the primary FML, should meet the permeability requirements of the EQC policy, provided its installation is performed in conjunction with a QA/QC program. However, a geotextile layer (or other cushioning material) may be required above the liner to reduce the potential for damage from the overlying leak detection system permeable materials. The use of a secondary FML directly on top of a low permeability clay liner, often referred to as a composite liner system, has been shown to significantly reduce the rates of potential leakage through a FML, due to the close interface of the clay with the synthetic liner [Refs 7, 8]. Such use of a composite liner is generally considered good engineering practice, due to the clay's ability to close-up or fill-in around a FML defect and reduce, if not, mitigate leakage occurrence. This is in contrast to the discouraged practice of placing the synthetic liner directly over more permeable materials, with larger voids, such as aggregate drainage materials. Such materials do not provide as close of a contact with the FML, can encourage leakage to occur, and can further contribute to the deterioration of the defect [Ref 9].

The bottom soil/clay liner as proposed, is to be comprised of a 36-inch thick layer of soil/clay materials, with an ODEQ-proposed maximum permeability of 10^{-7} cm/sec. This permeability requirement should satisfy the EQC requirements by providing sufficient time for leak detection prior to toxic release into the environment. This proposed rule permeability requirement will require the use of soils with relatively large percentages of clay content. The permeability requirement will also require that the soils be subjected to large compactive efforts. It may also be necessary to provide additives such as bentonite or other soil or chemical admixtures to the soil, to achieve the permeability requirement. Once the liner is constructed, it will be necessary to maintain it in a moist condition to reduce the potential for desiccation cracking. This may be achieved by sprinkling the liner with water and covering it immediately with the secondary liner, or with some other material, such as sand, to retard moisture loss. The occurrence of desiccation cracking could result in the clay liner's permeability being in excess of the prescribed, 10^{-7} cm/sec permeability value. There is no guarantee that dessication cracking can be prevented from occurring in clay liners. However, the potential for moisture loss is generally reduced as the liner becomes thicker in depth, since drying of the outer liner surface does not affect the deeper clay particles as much, particularly the further away from the liner's surface and drying influences the deeper clay particles are. If desiccation cracking has been found to occur, and extends through the full profile of the liner, leachate escape (provided the secondary liner (FML) is defective) into the environment may immediately occur.

c) <u>Geotechnical Considerations (OAR 340 Triple-Liner System)</u>

Evaluations of the liner system with regard to geotechnical considerations were conducted including stability, sliding and slippage, as well as settlement and strength considerations.

A key component of analyses pertaining to stability, sliding and slippage is the interface friction angle, which represents the contact angle between two materials possessing frictional resistance. The higher the friction angle is, the more a material possesses an increased ability to withstand sliding. Generally, the interface friction angles along geomembrane contacts are lower than the individual material strengths and will control heap stability. For these types of interfaces, two friction angles are generally considered: 1) peak strength-friction angle; and, 2) residual strength-friction angle. The peak strength-friction angle represents the frictional angle corresponding to the material's peak strength, whereas, the residual friction angle represents the material's friction angle after its peak strength has been achieved and the material has just become mobile and started to slide. The residual friction angle is, most generally, always less than the peak angle. For some geosynthetic material and soil interfaces, movement on the order of one millimeter can cause the material to transcend from its peak strength to residual strength state.

The interface of the primary liner with the heaped ore and the underlying leak detection permeable material generally results in friction angles varying in the range of between 26 and 29 degrees for HDPE liners, for example, [Ref 4, 10], and will vary depending on the type of liner used. Stability is generally not a problem for this type of an interface, except on very steep slopes where textured liners may be indicated in lieu of standard "smooth" liners. Geotextiles are often used in conjunction with the primary liner to increase its puncture resistance to the ore, or underlying granular materials. A typical range of interface friction angle values for FML/geotextile interfaces is between 7.3 and 11.3 degrees [Ref 4, 10], and is dependent on the type of FML liner and geotextile used. As a consequence, the use of geotextiles to increase the FML's puncture resistance must be done with caution, due to the relatively low interface friction values that can result.

The secondary FML has two interfaces, an interface with the leak detection permeable material layer and one with the bottom clay liner. The interface angle for the FML liner and permeable material layer lies within the same of range of values as those values for the primary liner/ore interface (26 to 29 degrees). The FML secondary liner/clay liner interface friction angle can range from as low as 6 degrees to as high as 25 degrees, [Refs 4, 10], depending on the nature of the soil/clay liner and the FML material. Consequently, the FML/clay liner interface is most always analyzed (for stability purposes) as a potential failure surface.

The soil/clay liner and subgrade interface friction angle will vary, depending upon the material components of the subgrade and the soil/clay liner materials. In some cases this interface may be a potential failure surface. A summary of typical interface friction angle values, is provided in Table 1 for the various interfaces discussed.

TABLE 2-1
Interface Friction Values [Ref 10]

MATERIALS	*FRICTION ANGLE (°)*
PVC rough in contact with Clay	9.6* - 26.2
PVC smooth in contact with Clay	6.1* - 25
PVC rough in contact with Sand	25 - 27
PVC smooth in contact with Sand	21 - 25
PVC in contact with Ore	33
PVC rough in contact with Geo-textile	23
PVC smooth in contact with Geo-textile	21
HDPE in contact with Clay	13
HDPE in contact with Sand	17 - 27
HDPE in contact with Ore	26 - 29
HDPE in contact with Geotextile	7.3* - 11.3

** Residual Value*

Sliding or slippage of the liner system could occur as a result of overstressing the primary and secondary FML's, causing them to stretch or slip, primarily as a result of construction operations and ore being deposited on the pad [Ref 4, 10]. Sliding along the bottom clay liner/secondary liner interface may similarly occur, particularly for liner systems constructed on steeper sites. The integrity of the FML seams is important with regard to the stability of the liner system and pad. Overstressing of the seams can cause them to peel or tear, initiating slippage or sliding, which may result in a condition of instability. In addition, due to the plastic nature of the FML's, secondary, creep induced stresses may be experienced by the FML materials. Sequenced ore loading techniques can be utilized to reduce the potential for overstressing a particular section of the pad and underlying FML's by attempting to balance the ore-induced, incremental applied stresses throughout the pad. Since the loading of ore on the liner system can induce tensile stresses upon the liner components (particularly on steeper sites and side slopes) it is oftentimes important to ensure that the liner is not overstressed in any one particular part of the heap. Consequently, ore loading can be sequenced to ensure that the height, location and areal extent of the ore material are established in such an ordered manner so as to cause the liner system to be in equilibrium to the greatest extent feasible. As a result, frictional resistance (up to the near the peak strength of the interface) can be mobilized to restrain the liner from excessive tensile stresses and movement, which can lead to tears and pullout of anchorage. Sequencing may be especially beneficial for pads constructed on steeper sites.

Differential settlements of the pad may also occur, causing disproportionate stresses to be transferred to the liner system, which in turn can overstress the liner system's components and affect their integrities. Differential settlement may also affect the integrity of the leak detection piping system due to unequal settlements along its length. Kinking of the leak detection piping system, disconnections at the pipe joints or their complete pull-out, or unacceptable deflections along the length of the piping, may result, as may the occurrence of low points or sumps in the system. The occurrence of low points in the system may cause portions of the system to flow in a pressure flow configuration, as opposed to the more desirable configuration of gravity flow.

A properly designed pregnant (mineral-bearing) solution recovery system, situated between the primary liner and the ore, can reduce the amount of leachate head buildup over the primary liner and liner system as a whole. In addition, the system should enhance the stability of the heap, and reduce the potential for leachate seepage through the primary liner. A well designed surface leachate recovery system can serve as an effective mechanism against potential leak occurrences and/or the occurrence of more serious liner system problems. Proposed Rule OAR 340-43-065(6) specifies maximum hydraulic head of 24-inches within the heap.

d) Distress Considerations, (OAR 340 Triple-Liner System)

Evaluations of the proposed liner system were conducted with regard to the system's potential to be distressed. Evaluations of the liner system's degree of redundancy, including the system components, were considered relative to the system's response to the distressed conditions.

The proposed triple-liner system offers a high safety factor due to the replication provided by the three liners and the leak detection system. In addition, the bottom liner's prescribed 36-inch thickness of low permeability soil/clay materials provides a high degree of protection to the environment, in the event leachate escapes through both the primary and secondary liners. The placement of the secondary liner directly on the top of the bottom clay liner (providing a composite liner) should effectively reduce the amount of leakage potentially escaping through a secondary liner defect, as a result of the close FML/clay liner interface. The FML liners, however, could be subject to punctures from both the overlying ore or the underlying permeable leak detection materials, if sufficient angularity of materials is allowed. The puncture resistance of FML's may be increased through use of geotextiles or other such cushioning materials. In this system, the primary FML represents the weakest component of the liner system due to its lack of protection (puncture resistance) both on its surface and underside, assuming cushioning materials are not utilized. Punctures occurring to the liner could potentially become larger and leakage rates more progressive with time, potentially leading to liner failure even with the use of cushioning materials. Where the primary liner is the weakest system component, it would be expected that the secondary and bottom liners, out of necessity, would need to provide a higher degree of secondary protection. The entire liner system would be better served, however, if the primary liner provided greater protection and was more reliable as a primary defense against leakage. Less reliance would then be placed on the other two liners, since the likelihood of their utilization as secondary defense mechanisms would be reduced. The leak detection system, which provides the second line of defense, should intercept leakage through the primary liner defect and convey it away from the defect. The utilization of a surface solution collection and recovery system, consisting of permeable materials and/or a perforated piping system (placed along the surface of the primary liner, beneath the ore) will further reduce the potential for seepage through the primary liner by reducing leachate head buildup in the ore. It would also enhance the heaped ore's stability by reducing the fluid levels within the ore, and is particularly effective where heap leaching is subject to wet weather conditions.

The leak detection and collection system proposed for the liner system, which consists of a combination of permeable drainage materials and a leak detection piping system, also offers a high degree of replication. This is because the permeable materials surrounding the piping system should in most instances possess the capacity to adequately convey leachate leakage by gravity flow to a collection point, even if the leak detection piping system were unable to function. This assumes, of course, that clogging of the material does not occur.

The leak detection and collection system should be able to well tolerate differential settlement of the liner system, since the components of the system are not as easily damaged from overstressing (as compared to the settlement effects on more rigid or thinner plastic materials).

Leak detection and collection piping systems have a long history of use in the mining industry, as well as in other industries. They are commonly utilized for other types of solid waste facilities including landfills and hazardous waste facilities. Such systems are currently used in conjunction with the recommended practices of numerous regulatory agencies including the EPA [Ref. 1]. In addition, the long term, in-ground deterioration potential for these types of systems, has been well documented over the years, as compared to a shorter history of use and documentation with regard to the deterioration potential of geosynthetic systems. Similar applications of these types of systems have also been widely utilized for other types of engineering projects. Such projects include, for example, public works and water resources related projects.

2.1.2.2 Operation, Maintenance and Repair Considerations (OAR 340 Triple-Liner System)

Evaluations of the liner system were conducted with respect to operation, maintenance and repair considerations, including those related to the closure/post-closure period.

Operation and maintenance of the proposed liner system should be uneventful, provided that QA/QC measures are subscribed to, during both the facility's operational life and post closure life. Puncturing of the primary liner is the most prevalent problem that occurs on heap leach pads, and generally results from wayward equipment operations, the dropping of equipment or tools on the liner, and the lack of use of cushioning materials to generally protect the liner's surface. As previously discussed, damage may also result from overstressing the liner with excessive heights of ore, or from excessively heavy equipment (which can result in punctures, tears or seam failures, for example).

Maintenance operations pertaining to the leak collection and conveyance channels, as well as the leak collection recovery piping systems, may also pose a threat to the primary liner, particularly if equipment or tools which can easily damage the liner are utilized during the maintenance operations. Damage to the secondary liner can similarly occur.

Procedures for maintaining the leak detection piping system (particularly after occurrence of a leak) should be relatively straight forward including standard pipe maintenance procedures, provided the pipe joints are contiguous and not separated. Hydraulic cleaning of the piping system should also be acceptable as a (post-leakage) maintenance procedure, provided water pressures are kept below the specified pressure level that would cause damage to the piping and the primary or secondary liners. In some cases, fines clogging the perforations of the piping system may be able to be backwashed from their locations by hydraulically flushing the pipe system. Also, hydraulic pressurization of the leak detection system may be utilized, to counteract the downward migration of leachate seepage from a defected primary liner. This may be accomplished by providing a hydraulic backpressure through the leak detection pipes at a pressure approximately equal to, or slightly in excess of, the leachate pressure head at the defect location.

Repair of the leak detection and collection piping system can generally be conducted by utilizing standard repair procedures and will generally not require the expertise of liner specialists. Typically, most repairs can be conducted by field personnel, including pipe installations, replacements and system extensions. If the piping is of sufficient diameter (generally 4-inches or greater) televised equipment may be transported through the piping system to assist with location of defects in the leak detection system or liner systems.

Typically, leach pads are constructed to function as a series of independent "cells" comprising the overall facility. As such, leaks can be easily tracked to an impacted cell through utilization of the leak detection piping system and strategically located observation points.

The leak detection piping system may also be utilized to assist in the identification of locations of liner defects, particularly from the detection of the leachate concentrations and volumes within a particular run of pipe, or for use in conjunction with dye tests used for identifying leak locations. In addition, the detection piping system may also be used in conjunction with acoustic emission tests, also used to determine defect locations [Ref 11]. Acoustic emissions tests utilize microphonic devices or piezoelectric sensors such as transducers to pick up the essentially inaudible vibrations of a leak as it makes its way through various materials (such as the leak detection piping system of a heap leach facility), and amplifies the sounds or vibrations to a remote station or recorder. In some instances, wave guides such as wires are utilized as a medium to be vibrated (throughout a facility) by the fluid as it passes, or collides with, the wire, yielding a detectable vibration.

The permeable material component of the leak detection system should protect the primary liner during tests or maintenance operations conducted on the leak detection system, due to the clearance and cushioning effect it provides between the piping system and the primary liner.

The leak detection system monitoring facilities are generally constructed of riser pipes (or in some cases may "daylight" to a sump) and are directly connected to the leak detection piping system or collection sump. The installation of these facilities (and operation thereof) should be compatible with the leak detection piping system, due to the relatively simple (standard pipe joints) connections between the two components.

In general, repair of geomembranes requires removal of the ore material from the liner (to expose the liner defect) in order to reseam or patch the liner. In some cases, drilling can be done in the immediate vicinity of the defect and a slurry, either bentonite or another suitable grouting material can be injected (through the casing) into the defect to reduce the leakage, or provide a barrier above and around the defect. However, due to the aggregate drainage material placed below many liners (utilized as a leak detection system), care must be taken to ensure the grout is not taken up to a large degree by the aggregate. This can be controlled as a function of slurry thickness, density and grout pressure.

Materials used for repair of the liner system (as well as for pad expansions and staged pad construction) may be stored and handled on-site with relative ease when compared to other types of materials such as geosynthetics.

With regard to closure/post-closure performance, the leak detection piping system should have far less potential for long term deterioration when compared to geosynthetic materials. The leak detection system's permeable material component provides a safety factor for the leachate detection and collection system, in the event that deterioration or clogging of the leak detection piping system would occur. The bottom clay liner also provides a safety factor with regard to post-closure operations, in the event that the primary and secondary synthetic liners would be adversely affected due to environmental conditions over the duration of the post closure period.

2.1.2.3 Construction Feasibility (OAR 340 Triple-Liner System)

The use of geosynthetic materials including flexible membrane liners (FML's) and geotextiles generally requires that experienced construction personnel (familiar with the particular geosynthetic product line and installation procedures) install the geosynthetic components of a liner system [Ref 12]. In addition, a detailed QA/QC program is generally conducted by a third party representative and utilizes standard tests and procedures to ensure that the quality of the materials and their installation(s), are adequate [Ref 12]. Geosynthetic construction materials are very delicate as compared to other types of construction materials. As a consequence, they are relatively easy to damage during transport, unloading, storage or installation. Even after their successful installation, what may be considered normal operations can be detrimental to the geosynthetic material's integrity, depending on thickness and composition.

Environmental factors (such as ultraviolet radiation, adverse weather conditions, and soil conditions, for example) can have a detrimental effect on particular types of geosynthetic materials. In general, most problems associated with geosynthetic materials are related to the seam strengths of the FML or geotextile sheets, and tearing or puncturing of the material from angular rocks or aggregates. In addition, damage may result from a lack of suitable foundation materials, voids beneath the liner, or from movement of the liner on steep slopes due to a lack of appropriate anchorage [Refs 1, 3, 6]. The QA/QC program should assist with reducing the potential for occurrence of these types of problems as well. Even a quality installation of a geosynthetic liner will in almost every case result in some occurrence of defects, however minor. Such defects can be kept from becoming progressively larger by providing cushioning with materials such as geotextiles or other acceptable materials, both above and below the liner. Ideally, the use of low permeability materials placed directly below the synthetic liner, and in close contact with it, will reduce the potential for the enlargement of the defects and significantly reduce the leakage [Ref 7, 9].

The proposed triple-liner system provides relatively good compatibility with staged pad construction methods and/or pad expansions. The components of system should permit fairly compatible connections with newly constructed pad components, while at the same time should permit some reasonable variance or tolerance during the construction process. The leak detection and piping system should permit relatively uneventful pad expansions, provided sufficient slope is available to permit gravity drainage for the new pad area's leachate collection and detection system. The liners should be relatively easy to connect to the new pad's liner components, since slight elevation variances between the new and old pads should be able to be taken up, to a large degree, within the thicknesses of the bottom clay liner or leak detection system.

Materials required to construct the leakage detection system should, generally, be readily available at most mine sites. The leak detection system layer should be relatively easy to construct in conjunction with the perforated piping system, provided adequate cover over the piping is maintained and excessively heavy equipment is cautiously used. If the permeable materials are too angular, geotextiles or other cushioning materials may need to be utilized to reduce the potential for damaging the primary and secondary liners.

Low permeability materials required to construct the 36-inch thick bottom liner will require that a clay borrow source be situated in the vicinity of the mine or that on-site soils possess the ability to be mixed with soil admixtures such as bentonite to achieve the 10^{-7} cm/sec permeability requirements of the liner. Otherwise, it will be necessary to import suitable low permeability materials from off-site locations. The construction of the clay liner should be carried out in conjunction with a QA/QC program to ensure that required performance properties (such as the permeability and strength of the constructed liner) can be achieved. Tests generally conducted include properties and gradation tests, compaction tests, laboratory permeability tests, and as deemed appropriate, in-situ permeability and shear strength tests.

The clay liner should be prevented, as much as is possible, from drying out after its construction, in order to minimize desiccation cracking occurrences, which could adversely affect the overall permeability of the liner. The liner should be maintained in a moist condition until the secondary liner or other appropriate materials can be placed over it, to retard the loss of moisture.

The use of cushioning materials such as sands or geotextiles placed on top of the primary and secondary FML liners should be considered during construction operations, to prevent damage to the liners. The cushioning will protect the secondary liner from the permeable leak detection drainage material and the primary liner from the ore.

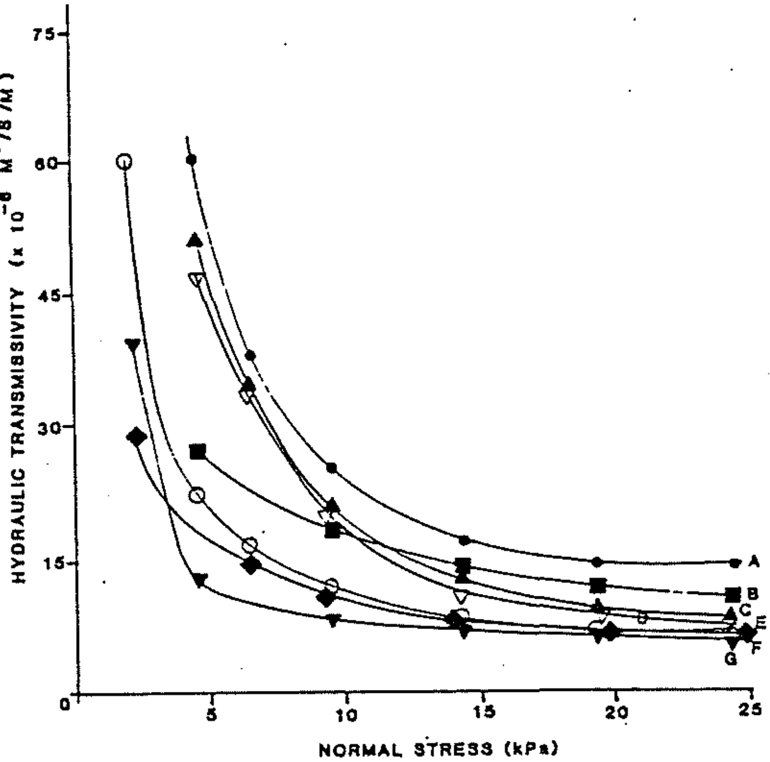
2.1.3 Proposed Double-Liner System

2.1.3.1 Performance Characteristics

a) Leak Detection System

The leak detection system as proposed for the double-liner system (as illustrated in Figure 1 (b)), utilizes a geotextile layer, leak detection system situated directly on the surface of the 12-inch thick proposed soil/clay bottom liner, and directly beneath the primary FML liner.

The geotextile material has the capability of transmitting the prescribed leakage rate of 400 gpd/acre, provided certain considerations are addressed prior to its use as a leak detection system. It has been shown that, in general, only nonwoven geotextile materials possess sufficient hydraulic capacity to convey significant amounts of planar flows [Ref 13, 14]. However, since the nonwoven geotextiles are extremely compressible when subjected to large loadings similar to those experienced on a heap leach facility, the conveyance capacity of the geotextile will consequently decrease with time and the magnitude of loading, as depicted in Figure 2-2, [Reference 13]. In addition, the effects of a phenomenon referred to as "clogging" will also reduce the conveyance capacity of geotextiles. Clogging refers to the filling of the void spaces of the geotextile (which are used to convey planar flows) with those materials present in the adjacent layers of the liner system [Ref 6, 13, 29]. In this case, the clogging materials would originate from the primary liner and the clay bottom liner. Based on this infor-



Geotextile	Mass Per Unit Area		Nominal Thickness		Polymer	
	oz/yd²	g/cm²	Mils	mm	Type	Filament
A	16	540	210	5.3	PET	continuous
B	18	600	190	4.7	PET	staple
C	18	600	150	3.8	PP	continuous
D	16	540	160	4.1	PP	continuous
E	12	400	110	2.8	PP	continuous
F	14	470	130	3.3	PP	staple
G	16	540	110	2.8	PET	continuous

[Ref. 13]—*Transmissivity response versus applied normal stress for various needled nonwoven geotextiles, after Koerner and Bove* [5].

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GEOTEXTILE CONVEYANCE versus LOADING	FIGURE 2-2

mation, it is anticipated that for this liner system, intrusion of the primary and bottom clay liner materials into the geotextile would occur, in conjunction with increased stresses on the pad resulting from increased ore deposition. As a result, unless significant factors of safety could be applied to the design of the geotextile leak detection system, its use should be discouraged. Many papers have been published which discuss this shortcoming of the geotextile [Refs 4, 6, 13, 14].

As an option, geonet or alternative geodrain materials can be substituted (as an alternative geosynthetic material) for use as the leak detection system component of the liner system. Geonet materials differ in configuration from geotextiles in that they possess ribs which are spaced at wider intervals than the filament spacings of the geotextiles, providing greater flow capacity, and as such, are capable of achieving stated Commission policy at significant cost savings.

Similar limitations, however, have also been suggested with regard to the use of these materials as well, primarily due to their limited load carrying capacity and reduced leakage conveyance capacity [Refs 4, 13, 14]. However, if sufficient factors of safety are applied, in conjunction with their greater thickness and conveyance area (as compared to the geotextiles) their use may be acceptable under certain loading conditions. It should be noted however, that the long term reliability and deterioration potential of the geonet drainage systems have yet to be established [Refs 6, 13, 14]. If these questions can be successfully addressed, the geonets may provide satisfactory service, due to their capacity to convey large rates of leakage with a relatively small amount of head buildup in the leak detection system layer. This is a result of their openness and areal extent. Due to their areal extent beneath the leach pad liner system, geonets can generally provide sufficient leakage conveyance capacity even if other portions of the geonet system are blocked. Also, the flow velocities through the geonet materials are substantially greater than the flow velocities through the permeable material/leak detection piping system and geotextile layers previously discussed. As a result, leakage travel times from a liner defect area to a monitoring well location should be substantially reduced with their use. In addition, the presence of fines should not affect the geonet's conveyance capacity as much as their presence would affect geotextiles and permeable drainage material/pipe detection systems. However, larger materials may cause blockage of portions of the geonet system, particularly if geotextiles or other protective materials are not utilized above the geonet layer.

Both geotextile and geonet materials have the potential to be damaged from environmental factors, including ultraviolet degradation and adverse weather conditions, in addition to those potential problems which might occur during their storage, handling and installation. In addition, certain geotextile materials have the potential for deterioration from bacteria, fungi and the chemistry of the soil [Refs 1, 3, 6]. As a result of the geotextile's thinness, punctures or localized stress concentrations experienced by the primary liner would have a greater potential to be transmitted through the geotextile to the clay bottom liner. This could cause subsequent puncturing or localized stress cracking to occur in the bottom liner [Ref 7].

b) <u>Permeability Considerations (Double-Liner System)</u>

The liner system's ability to meet EQC policy with respect to permeability was evaluated for each system component, including the primary liner, geotextile leak detection system, and the bottom clay liner.

Since the primary (or top) liner proposed for the liner system is to consist of a continuous FML geosynthetic liner, it should have a permeability substantially less than 10^{-7} cm/sec, provided it is installed in accordance with appropriate QA/QC measures. The evaluation of the permeability requirements for the OAR 340 triple-liner system primary liner (as presented in Section 2.1.2.1) is directly applicable to this system's primary liner, including the provisions for geotextile use or cushioning above the liner, QA/QC procedures and the surface solution collection system. It should be noted however, that the geotextile's use beneath the primary liner should act as a cushion between the primary liner and the clay bottom liner, up to that stress level where loading conditions (a function of heap height, etc.) surpass the geotextile's capacity to cushion the liners.

The geotextile layer proposed for use as a leak detection system is considered questionable with regard to its ability to meet the ODEQ proposed rule permeable zone requirements (minimum 10^{-2} cm/sec) and the Commission policy statement. As was previously discussed, the geotextile's conveyance capacity is dependent on the loading conditions applied. This results from the compressible nature of the nonwoven geotextile materials [Ref 13]. In addition, the effects of clogging intrusion from both the primary and clay liners into the geotextile or geonet need to be considered with respect to the reduced transmissivity of the materials. It is reported that turbulent flow conditions can occur for planar flow through geotextiles, particularly at higher hydraulic gradients, consequently causing a decrease in the geotextile's conveyance capacity [Ref 15]. Also, clogging of the geotextile (from fines transported with the defect leakage or from the underlying clay liner) should be evaluated in this regard [Refs 1, 13, 14, 15]. Intrusion of adjacent materials into the geonet materials will also reduce the transmissivity.

The 12-inch thick, bottom clay liner, as proposed, is to possess the ODEQ proposed rule maximum permeability of 10^{-7} cm/sec, and should be able to achieve the permeability and leak detection requirements of the stated Commission policy, provided the issues as discussed for the evaluation of the OAR 340 triple-liner system's bottom clay liner are considered (due to their similarities). Since the bottom clay liner is separated from the primary liner and the ore by only the thin geotextile layer, it is possible that damage to the primary liner could also result in damage to the bottom clay liner. As a result, stress cracks or indentations may occur, which could adversely affect the bottom liner's permeability characteristics. In addition, flow of leakage along the geotextile could cause erosion of the surface of the bottom clay liner, potentially leading to movement or damage of the primary liner. Wicking of leakage into the bottom clay liner is also likely to occur due the geotextile's location along the surface of bottom clay liner [Ref 15].

c) Geotechnical Considerations (Double-Liner System)

Evaluations of the double-liner system with regard to geotechnical considerations (including stability, slippage, settlement and strength considerations) were conducted for each component of the system.

The effects of the liner system (on the stability of the heap leach unit) due to the primary liner's interface(s) with the heaped ore and geotextile leak detection system layer, were considered to be the same for this liner system as for the OAR 340 triple-liner system, with the exception that the friction angle for the primary liner/geotextile leak detection system layer will lie within the range between 7.3 and 11.3 degrees. The utilization of the geotextile leak detection system layer (as proposed for this liner system) results in a relatively low interface friction angle between the two geosynthetic material components, and could potentially have a significant effect on the stability of the facility.

The typical interface friction angle between the geotextile and clay liner reportedly lies between 23 and 30 degrees, [Ref 4, 10]. As a result, stability is generally not a concern along this type of an interface, except for facilities constructed on relatively steep slopes. However, movement of the geotextile may be initiated along the interface as a result of other factors, including erosion of the clay bottom liner or movement of the geotextile resulting from overstressing of the seam. Also, tears and punctures would have an obvious detrimental affect on the stability of the interface. In addition, clogging or intrusion of the FML and clay bottom liner materials into the geotextile or geonet could cause asperities to develop, thereby reducing the interface friction of the interface.

The clay bottom liner/subgrade interface friction angle values are a function of the subgrade (site) materials the clay liner is constructed upon. As a result, the construction of the clay bottom liner on smoother subgrade materials may result in low interface friction angles, potentially affecting the stability of the facility. Typical interface friction values for the liner system components were previously presented in Table 1.

Sliding or slippage of the liner system may occur as a result of overstressing the primary FML liner and the geotextile leak detection system, either during construction of the liner system or during deposition of the ore on the pad. Overstressing may cause movements and subsequent tears, or overstressing of the seams of both the primary liner and geotextile. In addition, creep of the primary liner and geotextile or geonet may contribute to movement, particularly for facilities constructed on steeper sites.

Differential settlements occurring to the liner system could cause kinking or over-stressing of both the primary liner and geotextile or geonet materials, causing either tears or seam separation. Kinking could cause a loss of conveyance capacity in the geotextile/geonet, (particularly at the kink location) due to the reduction of its cross-sectional conveyance area.

As was discussed in the proposed OAR 340 triple-liner system evaluation, an effective surface solution collection and recovery system can reduce the buildup of hydraulic head over the primary liner and liner system. A surface solution collection and recovery system should also enhance the stability of the heaped ore.

d) Distress Considerations (Double-Liner System)

The proposed double-liner system offers a low degree of replication, principally due to the geotextile material's use as a leak detection system. The utilization of the geotextile as a leak detection and collection system is generally not recommended due to potential occurrence of problems, as previously discussed. It was determined in those discussions that the geotextile leak detection system (as proposed) could potentially jeopardize the bottom clay liner's functionality in the event of a leakage occurrence and may deteriorate the integrity of the liner as a result of the leak detection system's potential to cause erosion of the liner. In addition, clogging and/or intrusion of the clay bottom liner into the geotextile or geonet may occur. Also of importance is the lack of sufficient depth of cushioning between the clay bottom and FML primary liner. That is, the clay bottom liner could be susceptible to the same potential damage to which the FML primary liner is exposed, as a result of the very minimal separation between the two. The reduced thickness of the clay bottom liner (12-inches) also reduces the factor of safety with regard to desiccation cracking, stress cracking and indentation, in addition to a relative reduction in the breakthrough time of leachate, (as compared to the 36-inch thick liner utilized in the OAR 340 triple-liner system).

Other potential distress occurrences in the double-liner system may include overstressing of the primary liner, including the seams. This distress could be simultaneously experienced by the geotextile material (due to its close proximity to the primary liner), adversely affecting its function. Consequently, both components have the potential to be subjected to, and similarly affected by, the same distress-causing agent [Ref 7].

2.1.3.2 Operation, Maintenance and Repair Considerations (Double-Liner System)

Operation and maintenance of the double-liner system is also questionable due to the thinness of the geotextile leak detection and collection system layer. Although the potential for puncturing of the primary FML liner may be reduced (due to the presence of the geotextile and the underlying clay bottom liner) damage from forces which are in excess of the geotextile's strength may occur to these underlying components, as well. For example, damage to these underlying components may result from overstressing the primary FML liner, due to the intimate contact of the system components. Repair of the primary FML liner may be more difficult as well, due to the close proximity of the components. Also, repairs to the geotextile layer may be more difficult to carry out and could threaten the integrity of the primary FML liner.

Repairs to the leak detection system geotextile layer will generally require the use of geosynthetics repair specialists. Unclogging of fines from the geotextile layer for example, may be difficult, if not impossible, and replacement of a clogged section may be required. Utilization of hydraulic backpressures for cleaning or remediation of the leak detection and collection system is questionable, due to the thinness of the geotextile and its close contact with the primary FML and bottom clay liners (which might be damaged during the process). Storage and handling of the geotextiles may affect the materials. Also, certain geotextile materials are sensitive to ultraviolet radiation from sunlight, weathering, and temperature cycles.

Due to its continuous and unsegmented nature, the utilization of the geotextile for determining leak locations is limited. In addition, the ability to utilize the geotextile leak detection system for assisting with acoustic emissions testing may be limited, due to the thinness of the layer [Ref 11].

The double-liner system would be more difficult to tie into future pad expansions due to the thinness of the system's leak detection layer and lack of the liner system's substantial thickness. Also, riser pipe monitoring wells could be more difficult to connect to the geotextile layer (due to its thinness and the differences in the compatibilities of the more flexible geotextile material and rigid piping). The potential for damage to the geotextile (or its seams) is more likely to occur, as a result of the necessity of such a connection.

The long term deterioration potential of the geotextile has not been time proven, due to its short history of use [Refs 1, 14]. In addition, there are no provisions to ensure that the leak detection system will continue to function, in the event the geotextile material would deteriorate during its operational or post closure life.

2.1.3.3 Construction Feasibility (Double-Liner System)

The feasibility of constructing this double-liner system is, in general, equivalent to that of the proposed OAR 340 triple-liner system, with a few exceptions. The installation of the geotextile materials will require the use of specialized construction personnel in addition to the utilization of a conscientious QA/QC and testing program to ensure construction quality control.

The improper handling and storage of the geotextile materials, as with the other geosynthetic materials, can easily cause them to be damaged. Appropriate care should also be taken to protect the materials from construction equipment and personnel, as well as from prolonged ultraviolet (sunlight) exposure, weathering, and heating/cooling cycles. Geotextiles are not as readily available as conventional construction materials and generally require more quality assurance tests (due to considerations such as seam strength, etc.). In addition, other significant influences or effects, such as clogging and intrusion of the primary and bottom liners into the geotextile drainage layer, must be addressed during both the design and the construction of the double-liner system.

2.1.4 Alternative Candidate Liner System

2.1.4.1 <u>Performance Characteristics (Alternative Candidate Liner System)</u>

a) Leak Detection System (Alternative Candidate Liner System)

The leak detection system as proposed for the alternative candidate liner system is comprised of a 12-inch layer of permeable material possessing the ODEQ proposed rule minimum permeability of 10^{-2} cm/sec, utilized in conjunction with a leak detection piping system. The leak detection system is situated above a 12-inch thick bottom clay liner with a maximum permeability (equivalent to the ODEQ proposed rule) of 10^{-7} cm/sec, and below the composite FML/clay primary or variable thickness secondary clay liner component. The clay secondary liner, as proposed, possesses a maximum permeability of 10^{-7} cm/sec and is of sufficient (variable) thickness to provide adequate contact and strength for the overlying FML primary liner. The purpose of the secondary clay liner is to mitigate potential leakage from the primary FML liner [Refs 7, 8]. A continuous layer of geotextile or other cushioning material may be utilized between the leak detection layer and both the overlying and underlying FML liners, when, for the anticipated loads, the puncture resistance of any one of the three liners is anticipated to be exceeded. In addition, a geotextile layer or cushioning layer may be indicated under certain conditions for use above the primary FML as well, to improve its puncture resistance during ore loading and operations activities. It is recommended that puncture resistance tests be performed to determine the necessity of the geotextile or cushioning layer. The tests should utilize representative ore samples and permeable materials to be used in construction of the leak detection system. Also, the thickness of the secondary clay liner (which underlies the primary FML) should be determined based on sound engineering considerations related to the specific performance requirements for the specific facility and anticipated loading projections. In general, it would be anticipated to range in thickness from approximately 1/8 inch (when implemented as a prefabricated FML/bentonite composite liner) to as much as 6 inches (when implemented as a soil/clay liner underlying the FML). These engineering considerations should ensure that the required strength and permeability requirements of the composite liner system can be maintained for the system to function as an integral unit for the proposed loadings, uses, and site specific environmental conditions.

The leak detection system (as proposed for this liner system) is the same as the leak detection system which was proposed for the OAR 340 triple-liner system. Optionally, and where anticipated site and loading conditions allow, use of an engineered geodrain leak detection system may be implemented in lieu of the 12-inch layer of permeable material. As a result, the evaluation of this system's leak detection system reflects that presented for the OAR 340 triple liner system in Section 2.1.2.1. A geodrain leak detection system (in comparison to graded aggregate as proposed in the OAR 340 triple liner system) provides equivalent capability in achieving stated Commission policy while providing significant economic advantage. Further, a geodrain leak detection system offers at least one advantage over the aggregate in that it will contribute to greater reduction in hydraulic head over the lower component of the liner system, in the event leakage occurs.

b) Permeability Considerations (Alternative Candidate Liner System)

The composite liner is the equivalent of a double-lined system, consisting of a continuous flexible membrane primary liner in direct contact with, or fabricated with, an underlying secondary clay liner. The FML primary liner possesses, on average, a permeability of 10^{-11} cm/sec, while the clay secondary liner possesses a maximum permeability of 10^{-7} cm/sec. The function of the secondary clay liner is to minimize, or inhibit, leakage through the primary FML, in the event of a defect (such as a puncture).

It has been demonstrated that the presence of a low permeability clay liner directly beneath and in close contact with a FML significantly reduces or eliminates the amount of leakage through the primary FML [Ref. 7, 8]. This is a result of the underlying clay's tendency to close up, or fill in by swelling, the primary liner defect upon being wetted by the leak. In many cases, the leak becomes virtually undetectable. Conversely, it has been shown that for FML liners situated over more permeable materials (as with the OAR 340 Triple-Liner System) the FML primary liner defects tend to progressively worsen, causing greater amounts of leakage to occur [Ref. 9].

The leak detection system (as proposed for this alternative candidate liner system) should be able to satisfy the stated Commission policy, subject to the same considerations presented in Section 2.1.2.1 (b), pertaining to the gradation requirements of the permeable material, the percentage of fines present, and to clogging of the leak detection piping system. The proposed leak detection system is identical to that proposed in the OAR 340 triple-liner system. As indicated previously, use of a geodrain leak detection system may be appropriate under given conditions; such a system should achieve the proposed rule permeability requirements and may provide certain operational advantages along with economic benefits, as discussed earlier.

The bottom clay/soil liner (as proposed for this alternative candidate liner system) is similar to the 36-inch thick bottom liner which is proposed for the OAR 340 Triple-Liner System, with the exception that it is 12-inches in thickness. This bottom liner should satisfy the stated Commission policy with respect to permeability, subject to the considerations presented in Section 2.1.2.1 (b) for the OAR 340 triple-liner system. It should be noted that in these thickness ranges, a reduction in thickness of the liner would not affect the permeability, but would correspondingly lessen the travel time of any potential leakage through it. Assuming saturated conditions and a hydraulic head buildup of 12-inches over the proposed bottom liner (utilizing Darcy's law) it would take approximately 5 years for the wetted front to traverse the 12-inch thick liner, as opposed to approximately 22 years to traverse the 36-inch thick liner. As a result of these relatively long travel times (for either liner thickness) it is demonstrated that even the shorter 5-year breakthrough travel time period provides sufficient time to remediate a leak.

c) Geotechnical Considerations (Alternative Candidate Liner System)

Evaluations of the alternative candidate liner system with regard to geotechnical considerations were performed, including stability, slippage, settlement and strength considerations for each liner system component.

The utilization of the surface composite liner system, comprised of a FML primary liner underlain by a clay secondary liner, will result in an average interface friction angle value ranging between 6 and 25 degrees, depending upon the type of FML used and the clay liner's soil properties [Ref. 4, 10]. If a geotextile is utilized above the FML to increase its puncture resistance from the ore, an average FML/geotextile interface friction value between 7.3 and 11.3 degrees will result. Average friction values for the ore/FML interface would range from 26 to 29 degrees without the utilization of the geotextile. For the clay/geotextile layer interface, a friction value lying between 23 and 30 degrees may be expected. The geotextile-permeable material layer interface function value is estimated to range in excess of 25 degrees, depending on the angularity of the permeable materials.

The permeable material-geotextile interface along the surface of the bottom clay liner should result in interface friction angles in excess of 25 degrees, whereas, if the geotextile is not utilized, the interface angle of the permeable material and clay surface would be expected to be in excess of 25 degrees, as well. The interface friction angle between the geotextile (if utilized) and the bottom clay liner would be expected to range between 23 and 30 degrees. The interface friction angle between the bottom clay liner and the subgrade material will vary, depending on the composition of the subgrade.

Sliding or slippage of the liner system may occur as a result of overstressing the primary FML (including the seams) either during construction or pad operations. Sliding may also occur along the interface of the FML/clay composite liner if the interface friction angle between the two liners is relatively low. Creep of the primary liner may also contribute to sliding or slippage, particularly on steeper pads. If geotextiles are utilized to increase the puncture resistance of the FML and clay liners, then the potential for sliding should be investigated relative to the geotextile/FML interface and the geotextile/clay (bottom) liner interface. If the geotextiles are utilized, they could also be subject to the creep effects.

Differential settlement experienced by the liner system could result in overstressing of the FML's, clay subliners and geotextile layers, possibly resulting in tears or seam separations in the geosynthetics, or cracking of the clay subliners. Also, the leak detection piping system could be affected by differential settlement which could cause kinking, separation of the pipe joints, or unacceptable deflections along the length of the piping system (creating low points and locales of pressure flow).

An effectively designed solution collection and recovery system should be utilized above the composite primary liner to reduce the buildup of head over the liner system and to enhance the stability of the heap.

d) Distress Considerations (Alternative Candidate Liner System)

Evaluations of the alternative candidate liner system were made with regard to the system's potential to be distressed, including considerations such as component replication and the components' anticipated response(s) to such distress.

The proposed liner system is essentially a triple-lined system with a composite liner offering a relatively high degree of replication due to the use of the composite liner. In addition, the leak detection system layer offers a high degree of replication due to the combined use of the permeable drainage material and the leak detection and collection system piping system. The bottom clay liner provides adequate protection to the environment and has been reduced in thickness to 12-inches (from the OAR 340 triple-liner system's 36-inch thick bottom liner requirement) to reflect the greater protection factor provided by the surface composite liner. In addition, the bottom clay subliner should be well protected (by the 12-inch leak detection system layer) from potential puncture, indentation and cracking from surface impacts.

2.1.4.2 Operation, Maintenance and Repair Considerations (Alternative Candidate Liner System)

Both operation and maintenance of the alternative liner system should be relatively straight forward, provided appropriate QA/QC measures are observed during its operational (and post closure) life to minimize the potential for damage to the primary composite liner and leak detection systems. The operation, maintenance and repair considerations evaluated for this system are identical to those developed for the OAR 340 triple-liner system discussed in Section 2.1.2.2. It should be noted that the composite liner should provide excellent long term protection from damage through the closure/post-closure periods, due to the attached clay secondary liner's ability to reduce leakage from punctures occurring to the primary FML liner.

2.1.4.3 Construction Feasibility (Alternative Candidate Liner System)

The feasibility of constructing the alternative candidate liner system would be similar to that of the OAR 340 triple-liner system. An exception would be the potential for use of prefabricated composite liners, such as FML/bentonite composite liners [Ref. 15, 16, 17]. Prefabrication of composite liner components can enhance the resulting quality of a liner system's construction, due to its subjection to close factory tolerances and quality control measures during the manufacturing process. The other considerations for the feasibility evaluation are given in Section 2.1.2.3 of this document (as presented for the OAR 340 triple-liner system's construction feasibility).

2.2 Evaluation of the Liner Systems' Ability to Meet Commission Policy

2.2.1 Introduction

In order to address Question 2, (Will each of the various liner systems meet the stated EQC policy?), the technical reviews evaluated each of the three liner systems' ability to meet the Commission policy requirements, as discussed in the following subsections.

2.2.2 Proposed OAR 340 Triple-Liner System

As a result of the evaluation, it has been determined that the triple-liner system generally meets the stated Commission policy requirements. However, there are situations (discussed following) that could arise in which the system could potentially fall short of meeting these requirements.

The triple-liner system's primary liner is determined to be the weakest component of the system, due to the fact that it is situated directly above the permeable drainage material component of the leak detection system. Consequently, in the event of a primary liner defect, leakage would occur at a greater rate and most likely become progressively worse (as compared to a design configuration where the primary liner is situated directly over and in direct contact with, a layer of low permeability materials). Direct contact with an underlying low permeability layer has been shown to diminish the deterioration potential of such defects and the resulting rates of leakage. In addition, the use of geotextile or other cushioning materials to protect and increase the puncture resistance of both the surface and undersides of the primary liner may be necessary, particularly if the design puncture resistance of the FML is exceeded due to excessive loadings, or errant operations or accidents on the pad such as dropped tools, cigarette burns, etc. The surface of the secondary liner which is situated immediately below the leak detection layer, should in turn be provided with a geotextile protective or cushioning layer, to decrease the likelihood of puncture.

The leak detection and collection system may be subjected to clogging with fines during the occurrence of a leakage event. The flow of fines (with the leak) could emanate from the ore or permeable drainage materials utilized for the construction of the leak detection system. Clogging of the system could cause the permeability of the leak detection drainage materials to decrease to below the minimum (free draining) permeability value of 10^{-2} cm/sec. In addition, clogging of the perforations of the leak detection piping could occur, thereby affecting the system's effectiveness to collect the leakage from the permeable drainage materials. The piping system's ability to detect the prescribed leakage rate of 400 gpd/ac, within the prescribed 10-week time period, could be adversely affected. The utilization of filter materials and fabrics, graded filter criteria, and/or reduction in the percentage of fines present within the permeable drainage materials (as a material gradation requirement) would reduce the potential for such occurrences.

2.2.3 Proposed Double-Liner System

Evaluation of the technical review conducted for this double-liner system indicates that it would have difficulty meeting the stated Commission policy requirements. This determination results partly from the fact that the system is neither triple nor composite lined, in conjunction with a bottom soil/clay liner of 12-inches in thickness, (as opposed to the ODEQ proposed requirement of 36-inches). While the 12-inch bottom liner would prevent leakage from entering the environment for a period in excess of 5 years, that would be subject to the liner's and leak detection layer's sustainable integrity. As discussed, the bottom liner's integrity is susceptible to damage due to its direct contact with the overlying primary FML. In addition to these deficiencies, the system's leak detection system (proposed to be comprised of a geotextile layer) is questionable, due to the potential for a reduction in the system's transmissivity (which is due to the influence that the loading of ore will have on the compressive state of the geotextile) and the potential for intrusion of the surrounding materials, eventually clogging the system. Further, use of the geotextile material as a drainage medium directly on the surface of the 12-inch bottom clay liner could potentially contribute to erosion of the bottom liner. Due to the thinness of the geotextile material, and otherwise lack of a cushion between the clay bottom liner and primary liner, the bottom clay liner is also highly susceptible to ultimate damage from causes inflicting damage to the primary liner (such as indentations, punctures, or stress cracking).

2.2.4 Proposed Alternative Candidate Liner System

The alternative candidate liner system was evaluated with regard to meeting the requirements of the Commission policy. The double-lined composite system is comprised of a composite primary

FML and secondary clay liner. The secondary clay liner, situated directly below and in direct contact with the primary FML, has the ability to significantly reduce the rate of leakage through primary FML defects, in the event that damage (such as puncturing) occurs to the primary liner. Reduction in the leakage rate through the defect would be generally attributable to the composite liner's ability to close-up the defect when wetted by the leakage. Although the secondary liner may be susceptible to damage affecting the primary liner (due to its direct contact) it is still considered more effective to utilize a secondary liner in a composite liner configuration, as opposed to utilization of a primary FML directly over permeable materials, such as proposed for the OAR 340 triple-liner system [Ref. 7, 8, 9].

The leak detection system proposed for this alternative candidate liner system is the same as that proposed for the OAR 340 triple-liner system. As a result, the potential for clogging of this system should be evaluated, as discussed in Section 2.2.2. Where an engineered geodrain leak detection system is considered, similar evaluation should be conducted.

In the event that both the composite liner and leak detection components of the liner system failed, the 12-inch thick bottom clay liner would prevent leakage from entering the environment for a period indicated to be in excess of 5 years. This time period should permit sufficient time to mitigate and/or remediate any defects in the liner system. This travel time estimate assumes a maximum head buildup of 1-foot over the bottom clay liner; saturated flow conditions; and has been determined using Darcy's Law.

2.3 Level of Certainty Evaluation for the Liner Systems

2.3.1 Introduction

Level of certainty assessments (in order to address Question 3) were conducted for each of the three liner systems, with respect to the three categories evaluated in the technical review sections: 1) Performance Characteristics; 2) Operation, Maintenance and Repair Considerations; and, 3) Construction Feasibility Considerations.

For the evaluation, a level of certainty rating was performed for each liner system component based on a rating scale, defined as follows: 0-(Failure); 1-(Poor); 2- (Average); 3-(Above Average); and 4

(Excellent). Various weighting factor scenarios were considered for each of the three categories, including equal and varied weighting factor schemes for each liner system component. This was done to gain insight as to the degree of sensitivity associated with each liner system component for a particular category evaluation. The weighting factors applied to each scenario utilized a 3-point scale with a value of 3 representing three times more weight or importance (as compared to the weighted value of 1, representing the least important component weight).

The following weighting factor scenarios were established: 1) Equal weights to all liner system components, (i.e. all components considered equal); 2) incremental descending weights from the primary liner component to the bottom liner component, (i.e. uppermost components considered as most crucial); and 3) incremental ascending weights from the primary liner component to the bottom liner component (i.e. lowermost components considered as most crucial).

Discussion of the assigned level of certainty ratings for each component of the three liner systems is presented in the following subsections for each of the three categories evaluated. Assigned level of certainty was multiplied by the weight factor for the component, resulting in a weighted average category score. Weighted average category scores were summed to attain a "total weighted score", which provides the relative level of certainty for the liner system. The greater the total weighted score, the greater the level of certainty (of achieving stated Commission policy) for the liner system.

Results of the analyses (Tables 2-2 through 2-4) indicate consistently higher categorical and total levels of certainty for the OAR 340 Triple-Liner and the Alternative Candidate Liner Systems, irrespective of the weighting scenario.

2.3.2 Proposed OAR 340 Triple-Liner System

a) Performance Characteristics Rankings

The primary liner was assigned a rating value of 2, since the liner was considered to be representative of only an average synthetic liner system based on its potential for puncture (resulting from the underlying permeable drainage material).

The leachate collection system was assigned a value of 4, due to its material makeup and replication (and particularly due to the provision of the leak detection piping system). The secondary FML and clay bottom liners were assigned a value of 4, due to the composite nature of the secondary liner component and the 36-inch thickness of the clay liner.

b) Operation, Maintenance, and Repair Rankings

The primary liner was assigned a value of 2, due to the fact that it would require somewhat cautious operations, and would require maintenance and repair procedures on an average frequency, primarily due to the liner being situated directly on top of the permeable drainage leak detection material. The leak detection system was assigned a value of 4 due to its relative ease in being operated, maintained and repaired (in the event of a leak), as compared to other types of leak detection systems. The secondary/bottom liner system was rated a value of 4, due to its thickness, composite liner nature, and the fact that it is well-cushioned (by the permeable leak detection drainage material) from potential primary liner damaging influences.

c) Construction Feasibility Rankings

A value of 2 was assigned to the primary liner due to its geosynthetic nature, and since its feasibility of being constructed in a quality manner would be only average, due to its installation directly over the leak detection permeable drainage material. A value of 3 was assigned to the leak detection and collection system layer, since its feasibility of being constructed in a quality manner would be expected to be above average. The secondary liner/bottom liner system was assigned a value of 3 since its feasibility of being constructed in a quality manner would generally be expected to be above average.

2.3.3 *Proposed Double-Liner System*

a) Performance Characteristics Rankings

A value of 3 was assigned to the primary liner since the utilization of a geotextile layer (in lieu of the permeable drainage material below the liner) would give the primary liner above-average performance characteristics. A value of 1 was assigned to the geotextile leak detection and collection system, due to its anticipated below-average performance and lack of recommendations in the literature for its use as a drainage medium under high loadings. A value of 2 was assigned to the secondary liner system, due to its 12-inch thickness and anticipated average performance.

b) Operation, Maintenance and Repair Rankings

A value of 3 was assigned to the primary liner since its operation, maintenance and repair suitability should be somewhat above average, due the presence of the underlying geotextile material and absence of underlying permeable drainage materials. A value of 1 was assigned to the geotextile leak detection and collection system, since its thinness will severely limit procedures which can be performed with regard to system operation, maintenance and repair after a leak occurrence. A value of 1 was assigned to the secondary/bottom liner system since it would be highly susceptible to damage from operations occurring on the primary liner (and due to the lack of sufficient cushioning between the primary liner and the bottom liner).

c) Construction Feasibility Rankings

A value of 3 was assigned to the primary liner, due to the presence of a geotextile layer below the primary liner and its positive effects on the installation quality of the primary liner. A value of 2 was assigned to the geotextile leak detection system, since the material will require numerous seams and will be situated directly on top of the clay bottom liner (which will make the feasibility of its installation only average). A value of 3 was assigned to the bottom liner's construction feasibility, due to the above-average expectation that it can be constructed in a quality manner, and with earthen materials.

2.3.4 *Alternative Candidate Liner System*

a) Performance Characteristics Rankings

A value of 4 was assigned to the primary liner due to the fact it is a composite liner, and is anticipated to perform very well. A value of 4 was assigned to the leak detection system due to its material makeup and replication (by virtue of the provision of the leak detection and collection piping system). The secondary/bottom liner system was assigned a value of 2 due to its 12-inch thickness and anticipated average performance.

b) Operation, Maintenance and Repair Rankings

A value of 4 was assigned to the primary liner system due its composite liner components; its expected reduction in damage to the liner from operations; and, its expected reduction in frequency of maintenance and repair operations. The leak detection system was assigned a value of 4 due its ability to be operated, repaired and maintained relatively easily, and particularly due to the use of the leak detection piping system. The secondary/bottom liner was assigned a value of 2, primarily due to the fact that it is relatively well cushioned from the potential damaging effects of pad operations (by the leak detection system layer) but has a 12-inch thickness.

c) Construction Feasibility Rankings

The primary liner was assigned an above average value of 3 due to its composite nature. The leak detection system was also assigned a value of 3 due to the relative ease associated with its construction. The secondary/bottom liner system was assigned a value of 3 due to its above average feasibility of being constructed in a quality manner.

2.4 Evaluations of Other Liner Systems

2.4.1 Introduction

To evaluate features of the previously discussed proposed liner systems, and to select an alternative candidate liner system for further evaluation, TRC reviewed a number of alternative liner systems (in order to address Question 4) and evaluated each with regard to its general ability to meet stated Commission policy requirements. Various liner systems were reviewed in the literature, including product information provided by manufacturers of geosynthetic materials. In addition, a review of liner systems as required by various state regulatory agencies was performed.

2.4.2 Alternative Liner Systems

As a result of the literature and product information review, it was determined that numerous liner system configurations are utilized throughout the U.S. and other parts of the world. Essentially, for the purposes of this report, the liner systems have been classified (according to their components) as being comprised of 1) earthen materials with little or no use of geosynthetic materials, 2) geosynthetic liner systems with little or no use of earthen materials and 3) combinations of the above liner systems (which includes composite liner systems). Discussions of these three types of liner systems are given in the following paragraphs.

a) Earthen Liner Systems

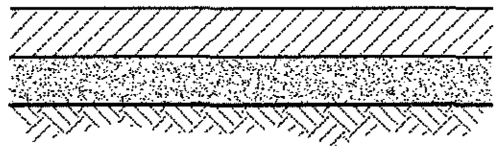
Earthen liners are comprised of compacted, low permeability natural soil materials and are used as either single or multiple liner systems. When multiple earthen liners are used, they are generally separated by a leak detection system consisting of permeable drainage materials (which often include leak detection piping systems). The leak detection piping system generally consists of perforated PVC or corrugated piping. The use of earthen liner systems, solely, is becoming less common [Ref 6], since their permeability is far in excess of the lower permeability that may be obtained with the use of synthetic liners. However, because of their greater thickness as compared to synthetic liners, their use permits longer breakthrough times in the event of a leak, which can be advantageous due to the increase in the time available to mitigate leakage to the environment. However, a major drawback is that by the time a leak may be detected, the defect in the system may be very dated. Synthetic liner systems, on the other hand, due to their extreme thinness and extremely short breakthrough times, will permit a leak to be detected much faster. Some typical earthen liner systems are illustrated in Figure 2-3.

b) Geosynthetic Liner Systems

Geosynthetic liner systems are comprised of synthetic liner components, such as flexible membrane liners, utilized in single liner or multiple liner systems, and are typically separated by a layer of synthetic drainage materials such as geonets or geodrains. Due to their polymeric or plastic nature, the liners possess very low permeability values. However, due to their thinness, leakage (through the synthetic liner, in the event a defect occurs) will have a very short breakthrough time, generally permitting immediate detection. In addition, the geosynthetic liner systems, when used by themselves, are relatively weak materials and must be engineered with extreme care (Figures 2-4 and 2-5) and often must be reinforced with geotextiles or geogrids, and when indicated, properly anchored to avert sliding. The use of geosynthetic liner systems, without the additional use of earthen materials, is often limited to pond liner applications due to the reduced and equal-all-around fluid pressures acting upon the liner. Potential for sliding and slippage is essentially due to the low interface friction angle that usually results between the synthetic materials. Typical geosynthetic liner systems are illustrated in Figure 2-6.

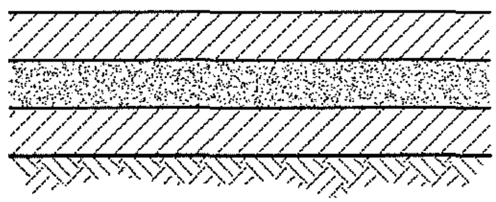
c) Composite Geosynthetic and Earthen Liner Systems

Over the past decade, various combination liner systems have been developed which utilize multiple components comprised of both earthen and geosynthetic materials. Essentially, the utilization of combinations of the two materials, as in a liner system, takes advantage of the low permeability of the geosynthetic materials and the strength and increased breakthrough time of the thicker, earthen material components. The



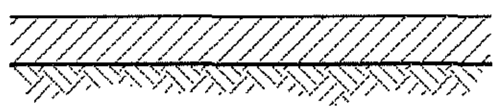
SINGLE LINER WITH LEAK DETECTION SYSTEM

(NOT TO SCALE)



DOUBLE LINER WITH LEAK DETECTION SYSTEM

(NOT TO SCALE)



SINGLE LINER WITHOUT LEAK DETECTION SYSTEM

(NOT TO SCALE)

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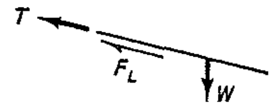
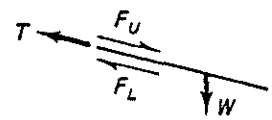
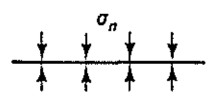
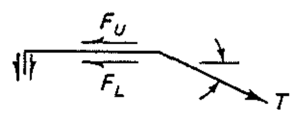
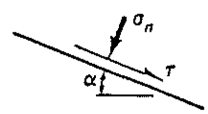
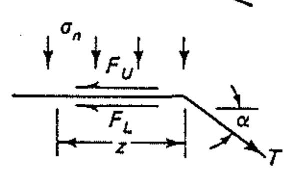
TYPICAL EARTHEN LINER SYSTEMS

FIGURE 2-3

[Ref 6] VARIOUS DESIGN MODELS FOR GEOMEMBRANES IN WASTE DISPOSAL SITUATIONS (REF: KOERNER AND RICHARDSON, 48)

Problem	Liner stress	Free body diagram	Required properties: Geomembrane	Required properties: Landfill	Typical factor of safety
1. liner self weight	tensile		$G, t, \sigma_{allow}, \delta_L$	β, H	10 to 100
2. weight of filling	tensile		$t, \sigma_{allow}, \delta_U, \delta_L$	β, h, γ, H	0.5 to 10
3. impact during construction	impact		I	d, w	0.1 to 5
4. weight of landfill	compression		σ_{allow}	γ, H	10 to 50
5. puncture	puncture		σ_p	γ, H, P, A_p	0.5 to 10
6. anchorage	tensile		$t, \sigma_{allow}, \delta_U, \delta_L$	β, γ, ϕ	0.7 to 5
7. settlement of landfill	shear		τ, δ_U	β, γ, H	10 to 100
8. subsidence under landfill	tensile		$t, \sigma_{allow}, \delta_U, \delta_L, \chi$	α, γ, H	0.3 to 10

Notes:

Geomembrane properties

- G = specific gravity
- t = thickness
- σ_{allow} = allowable stress (yield or break)
- τ = shear stress
- I = impact energy
- σ_p = puncture stress
- δ_U = friction with material above
- δ_L = friction with material below
- χ = mobilization distance

Landfill properties

- β = slope angle
- H = height
- γ = unit weight
- h = lift height
- α = subsidence angle
- ϕ = friction angle
- d = drop height
- W = weight
- p = puncture force
- A_p = puncture area

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ENGINEERING ANALYSIS of GEOSYNTHETICS

FIGURE 2-4

[Ref 6] VARIOUS DESIGN CONSIDERATIONS FOR DRAINAGE GEOCOMPOSITES (USUALLY GEONETS) IN WASTE DISPOSAL SITUATIONS [48]

	Problem	Reason	Approach	Required Properties: Geosynthetic	Required Properties: Landfill	Status of Problem
1.	strength of core	avoid crushing of core	$FS = \sigma_{ult}/\sigma_{max}$	σ_{ult}	γ, H	designable
2.	flow in core	first approximation	$FS = q_{allow}/q_{act}$	q_{allow}	γ, H, i, q_{act}	designable
3.	creep of core	first reduction	$FS = q'_{allow}/q_{act}$	q'_{allow}	γ, H, q_{act}	variable
4. (a)	elastic intrusion of geomembrane	second reduction	elastic plate theory	E, μ, x, y	γ, H, q_{act}	designable
(b)	elastic intrusion of geotextile	second reduction	elastic plate theory	E, μ, x, y	γ, H, q_{act}	designable
5. (a)	creep intrusion of geomembrane	third reduction	creep theory	$\dot{\varepsilon}(\sigma, t), x, y$	γ, H, t	unknown
(b)	creep intrusion of geotextile	third reduction	creep theory	$\dot{\varepsilon}(\sigma, t), x, y$	γ, H, t	unknown

Notes:

- Geocomposite properties
  - σ_{ult} = ultimate compression strength
  - q_{allow} = allowable flow rate
  - t = time
  - E = modulus of elasticity
  - μ = Poisson's ratio
  - x,y = core dimensions
  - $\dot{\varepsilon}(\sigma,t)$ = strain rate
- Landfill properties
  - γ = unit weight
  - H = height
  - i = hydraulic gradient
  - q_{act} = actual (design) flow rate
  - t = time
  - σ_{max} = maximum stress
  - σ = applied stress

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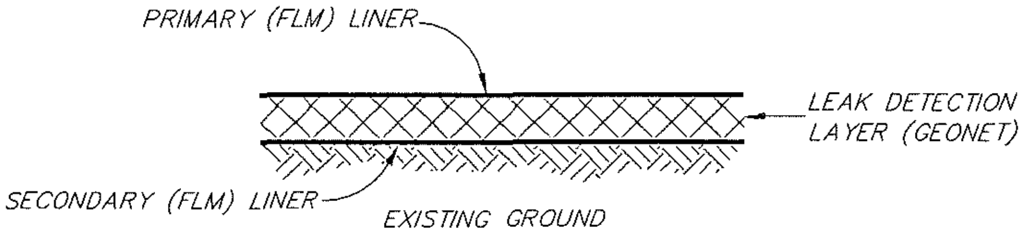
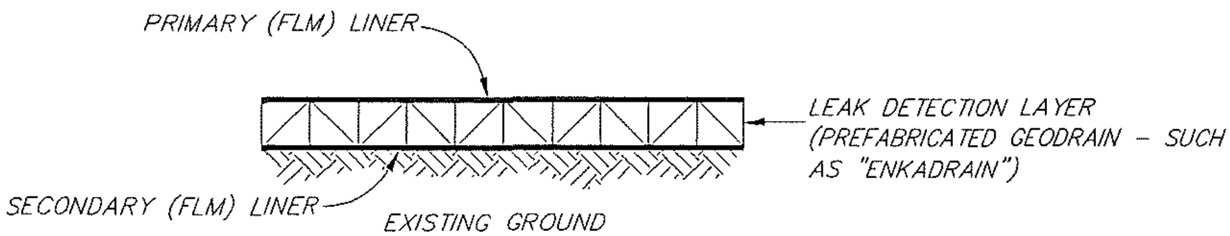
DESIGN CONSIDERATIONS

FIGURE 2-5



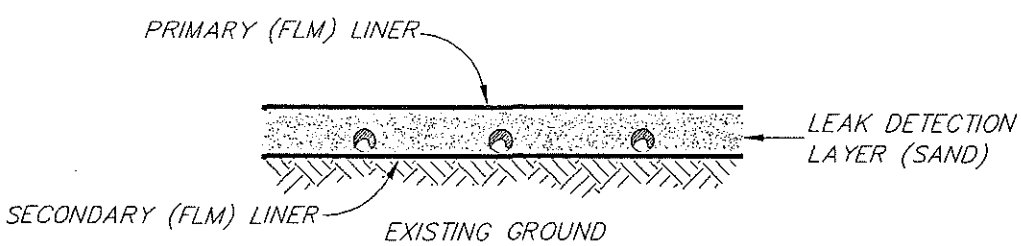
DOUBLE SYNTHETIC LINER WITH GEONET LEAK DETECTION SYSTEM

(NOT TO SCALE)



DOUBLE SYNTHETIC LINER WITH PREFABRICATED GEODRAIN LEAK DETECTION SYSTEM

(NOT TO SCALE)



DOUBLE SYNTHETIC LINER WITH SAND DRAIN LEAK DETECTION SYSTEM

(NOT TO SCALE)

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TYPICAL GEOSYNTHETIC LINER SYSTEMS	FIGURE 2-6

evolution of the combination liner systems over the years is illustrated in Figure 2-7 [Ref. 6]. It may be observed from these illustrations that synthetic materials were initially utilized as impermeable liner barriers in combination with conventional earthen liner systems. Since their initial use, however, the use of geosynthetic materials has evolved to include their use not only as liners, but as drainage layers (geonets), filters and protection layers (geotextiles), and for soil strengthening purposes (geogrids). In recent years, numerous variants of these basic geosynthetic components have evolved, including geodrains, composite liners and prefabricated composite liners [Ref. 18]. The utilization of composite liner systems has been proven to be effective in mitigating leakage from liner systems due to the close contact of the underlying clay subliner with the geosynthetic FML. It has been shown that leakage through a composite liner system is considerably less than the leakage resulting through an equivalent sized defect in an earthen (soil/clay) liner or a geosynthetic liner overlying permeable materials, for an equivalent head of leachate buildup over the defect [Ref. 7, 8]. It has been shown that, in general, the greatest amount of leakage will occur through the latter liner system (FML situated over permeable material). As a result, composite liner systems are generally recommended over other liner systems, with clay liners generally representing the second best alternative liner system. Geosynthetic liners used in conjunction with underlying permeable materials are considered the least desirable of all liner systems. Numerous types of geosynthetic drainage layers and leak detection systems have been developed over the years since the geotextile was primarily utilized for these functions. Geonets and other geodrain materials possessing greater cross sectional conveyance areas than geotextiles have been developed, including ENKADRAIN and others, for example [Ref. 18]. However, due to a lack of long term evidence related to their reliability, most waste facilities still utilize permeable natural materials such as aggregate and perforated leak detection piping systems for construction of the leak detection layer. In the future, as the long term reliability of synthetic drainage systems is proven, their utilization will most likely increase. This is partly due to the fact that the synthetic drainage systems possess a greater conveyance capacity as compared to permeable aggregate materials. As a result of this increased capacity, a reduction in leachate head buildup in the leak detection layer will result, minimizing the potential for seepage through the underlying liners. In addition, these systems should generally be less susceptible to clogging with fines, due to their areal extent and increased conveyance capacity, as compared to gravel drains, for example.

2.4.3 *Review of Other Jurisdictional Regulatory Requirements for Liner Systems*

A multi-state review of current regulatory requirements for heap leach liner systems was conducted to identify the types of liner systems which are considered acceptable by other states and jurisdictions. A summary of these liner requirements is presented in Table 2-5.

As shown in Table 2-5, for the majority of the state regulations reviewed, a double-liner system with a leak detection system is commonly required. Only a few states require utilization of triple-lined systems or double-lined composite systems. For the majority of the state regulations reviewed, leak detection systems are commonly required to be constructed of permeable materials and require a leak detection piping system. A few states permit the use of geotextiles and/or geonets for the leak detection system. It is reported that the State of Nevada has experienced success with operations employing geotextile and geonet leak detection systems [Ref 23].

Due to the wide range of liner system components, and the number of variables inherent in the design of any system, it is not possible to provide a quantitative assessment of breakthrough times associated with each state's requirements. However, TRC has compiled Table 2-6, providing a demonstration of the relationship between various liner system design variables. For additional comparative information, TRC notes that the New York State Department of Environmental Conservation has approved the prefabricated FML/bentonite composite liner as an equivalent substitution for the upper 6-inches of an 18-inch thick primary soil liner in sanitary landfill application [Ref 48].

2.4.4 *Liner Systems Capable of Meeting Commission Policy*

Based on the review of the literature, product information and the regulatory guidelines or requirements of other states and jurisdictions, several alternative liner system configurations were identified as being capable of meeting the Commission's Policy requirements, as depicted in Figure 2-8. It should be noted however, that any one particular liner system may not be appropriate at all facilities and/or sites, due to various site specific physical and engineering constraints. As a result, a liner system should be selected based on numerous design considerations particular to the site, including loading projections, geotechnical and construction considerations, as well as operation and maintenance considerations. For some loading scenarios, for example, the utilization of geonets may be acceptable

TABLE 2-5
Summary of Heap Leach Pad Liner Regulations for Other States

ARIZONA

Heap leach pads are required to be constructed over a double-lined system in which one of the liners must be a synthetic liner. A leak detection and recovery system is required between the two liners. Synthetic liners shall posses a minimum 30 mil thickness. Soil liners shall have a minimum thickness of 12 inches and a maximum permeability of 10^{-6} cm/sec.

CALIFORNIA

Heap leach pads are required to be constructed over a double-lined system, comprised of a 12 inch thick primary clay liner and either a 12 inch thick clay bottom liner or 60 mil synthetic bottom liner. Clay liners shall have a maximum permeability of 10^{-6} cm/sec. The two liners are to be separated by a 12 inch thick layer of gravel containing a leak detection and recovery piping system.

COLORADO

Heap leach pads are required to be constructed over a double-lined system consisting of a synthetic primary liner and either a 12-inch thick clay bottom liner or synthetic bottom liner. Synthetic liners shall possess a minimum thickness of 40 mils. Clay liners shall have a maximum permeability of 10^{-6} cm/sec. The primary and bottom liners are separated by a 12 inch thick layer of sand, preferably, and shall possess a minimum permeability of 10^{-2} cm/sec for use as a leak detection system. The use of geonet synthetic materials is permitted for use as leak detection and recovery system if sands are not available or slopes are steep. For reusable heap pads, the primary liner consists of an asphalt layer constructed over the 12 inch thick, sand leak detection system layer. The bottom liner is comprised of a 12 inch layer of clay, soil liner, with a maximum permeability of 10^{-6} cm/sec. A composite liner system, comprised of a synthetic liner over a 12 inch thick clay layer or a clay amended soil layer, without the requirement of the leak detection system, may be used in lieu of the above liner systems, with the exception of the reusable asphalt pad facility.

IDAHO

Heap leach pads are required to be constructed over a single-lined system. The single liner must possess a maximum permeability of 10^{-6} cm/sec and may consist of either a synthetic or earthen liner. A leak detection system is not required specifically as per the liner regulations, but may be required as part of the water quality monitoring regulations.

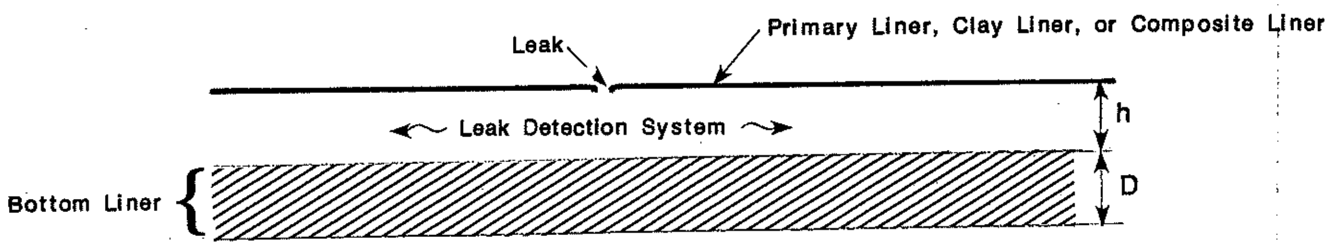
NEVADA

Heap leach pads are required to be constructed over a double-lined system. The primary liner must possess a maximum permeability of 10^{-7} cm/sec and may consist of either a 1 foot thick layer of clay liner or a synthetic liner. The bottom liner's specifications are dependent on whether or not a leak detection system, which is optional, is utilized in the system. If a leak detection system is utilized, then the secondary liner may be comprised of a 1 foot layer of soil liner materials possessing a maximum permeability of 10^{-5} cm/sec. If a leak detection system is not utilized, the bottom liner must be of the same thickness (1 foot) but possess a maximum permeability of 10^{-6} cm/sec. Synthetic leak detection systems such as geonets, for example, are permitted.

SOUTH DAKOTA

Heap leach pads are required to be constructed over a triple-lined system consisting of a minimum thickness, 60 mil synthetic primary liner situated over a gravel leak detection and recovery system. The gravel leak detection and recovery system is situated on top of a minimum thickness, 60 mil secondary synthetic liner. The secondary liner is situated directly on the bottom soil liner consisting of an 8 to 12 inch thick soil layer, constructed on compacted subgrade.

TABLE 2-6
Breakthrough Time Calculation for Saturated Flow Through Bottom Liner



Assume saturated flow through bottom liner:

$Q = K\,i\,A$ (*Darcy's Law will apply*)

$Q/A = v = K\,i$ (*velocity*)

$v = K\,i$ *where* $i = gradient = \frac{h + D}{D} = K(\frac{h + D)}{D}$

Now the breakthrough time is such that:

$v\,t = D$ (to traverse bottom liner)

$$t = \frac{D}{v} = \frac{D}{K(\frac{h+D}{D})} = \frac{D^2}{K(h+D)} = \frac{D}{K(\frac{h}{D}+1)}$$

In general, it can be stated that the breakthrough time (for saturated flow through a bottom liner) is dependent on numerous variables, however, it can generally be interpreted in the following manner:

- For an increase in bottom liner thickness, there is a corresponding net increase in breakthrough time;
- For an increase in thickness (or capacity) of the leak detection and collection system, there is a corresponding net decrease in breakthrough time;
- For a decrease in hydraulic conductivity (of the liner), there is a corresponding net increase in breakthrough time.

From this it is implicit that there are a number of methods (which can be translated as design alternatives, as substantiated by the range of technical approaches discussed in Table 2-5) for achieving the design objective of prohibiting release to the environment. Many systems rely upon configurations that allow adequate response time to mitigate a leak; conversely, many systems rely upon configurations that minimize potential for a leak.

for use as a leak detection system, provided it can be shown that sufficient conveyance capacity will be available after the pad has been loaded and that the long term reliability of the material will be acceptable. In other cases it may be beneficial to limit the use of geosynthetic materials altogether, and utilize other materials such as earthen materials for liner construction, particularly at locations which are subjected to severe temperature fluctuations throughout the year.

Of the liner systems identified as being capable of meeting the requirements of the Commission policy, (as depicted in Figure 2-8), the liner system consisting of the composite surface liner and earthen material bottom liner was selected for further evaluation as the best "Alternative Candidate Liner System". The evaluation of this liner system has been discussed throughout the preceding sections of this report. However, this liner system should not be construed as representative of the only acceptable alternative liner system. It is imperative that each liner system be designed and selected on a site specific basis and possess the capabilities of meeting minimum prescribed performance requirements.

2.5 Estimated Liner Systems Costs

Estimated costs for the installation of each of the three liner systems (OAR 340 triple-liner system; proposed double-liner system; and alternative candidate liner system) were developed. It should be noted that these estimates are based on equivalent materials and do not include transportation costs of materials to a site (which may be substantial in certain instances and may warrant selection of an alternative system component with equivalent performance characteristics).

It should be noted that based on this cost comparison, the aggregate leak detection system material is clearly the most costly component on a per square yard basis. It may also be observed that use of geosynthetic drainage layers substantially reduces the cost of this component, with the "geotextile" drainage layer being the least expensive component, on a per square yard basis. It has been demonstrated in previous sections that utilization of geodrain leak detection systems can achieve the stated Commission policy at significant cost benefit.

As such, for comparative analysis, the alternative candidate liner system was also evaluated with respect to installation cost where (1) geodrain materials are used in lieu of aggregate drainage materials (Alternative 1); and, (2) a prefabricated composite FML/bentonite liner is used in lieu of 6-inches of compacted soil/clay in the composite upper liner (Alternative 2). The comparative cost estimates for the various liner configurations are presented in Table 2-7.

TABLE 2-7
Comparative Cost Estimates
Liner System Installation

Representative Material	*Cost/Unit*	*OAR 340 Triple Liner System*		*Proposed Double Liner System*		*Alternative Candidate Liner System*		*Alternative Option 1 (Geodrain)*		*Alternative Option 2 (HDPE/Bentonite)*	
		Units	*Ext'd*	*Units*	*Ext'd*	*Units*	*Ext'd*	*Units*	*Ext'd*	*Units*	*Ext'd*
40 mil HDPE	$31.5/sq yd	2	$6.30	1	$3.15	1	$3.15	1	$3.15	1	$3.15
10 oz. Geotextile	$1.75/sq yd	0	0	1	$1.75	0	0	0	0	0	0
6" perf. pipe	$5.50/linear foot	0.22	$1.21	0	0	0.22	$1.21	0.22	$1.21	0.22	$1.21
12" perf. PVC	$9.38/linear foot	0.02	$0.19	0.02	$0.19	0.02	$0.19	0.02	$0.19	0.02	$0.19
6" - 12" T-joint	$96.00 each	0.0028	$0.27	0	0	0.0028	$0.27	0.0028	$0.27	0.0028	$0.27
3/4" gravel	$30/ton	0.63	$18.90	0	0	0.63	$18.90	0	0	0.63	$18.90
Soil/Clay	$7.50/cubic yard	1	$7.50	0.333	$2.50	0.5	$3.75	0.5	$3.75	0.333	$2.50
HDPE w/ Bentonite	$4.95/sq yd	0	0	0	0	0	0	0	0	1	$4.95
Geodrain	$3.78/sq yd	0	0	0	0	0	0	1	$3.78	0	0
Total Cost	Square Yard	- -	$34.37	- -	$7.59	- -	$27.47	- -	$12.35	- -	$31.17

3.0 QUESTIONS ON TAILINGS TREATMENT TO REDUCE THE POTENTIAL FOR RELEASE OF TOXICS

Evaluation of Technical Issue 2 involves review of the technical basis and merit of proposed rules requiring cyanide detoxification and reuse for mill tailings generated as a result of chemical mining processes within the State of Oregon. These proposed rules deal with, in particular, the use and control of alkaline, cyanide solutions, including specific requirements set forth for removal and reuse. Cyanide removal and reuse requirements are then further coupled with detailed specifications for liners and engineered "hazardous waste" management unit cover systems to prevent migration of toxic chemical and/or metals species to the environment.

The proposed regulations would require the reduction of cyanide levels by recovery and reuse technologies through employment of physical and chemical means. Issue 2 requires a review of the proposed rule requiring tailings treatment through cyanide removal and reuse, to: ascertain technical feasibility; ascertain the probable degree of the material reduction of risk of environmental degradation that the rules may enforce; determine the level of reliability of the proposed technologies and systems; and, suggest possible alternatives, where appropriate.

The Commission has established as policy that ".. the toxicity (as measured by weak acid dissociable (WAD) cyanide content) and potential for long-term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment." The proposed rules in OAR 340-43-070(1) state the following:

> "Mill tailings shall be treated by cyanide removal and reuse prior to disposal to reduce the amount of cyanide introduced into the tailings pond. Chemical oxidation shall be additionally used, if necessary, prior to disposal to reduce the WAD cyanide level in the liquid fraction of the tailings. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm."

The rules do not require removal of potentially toxic metals from tailings prior to placement in the tailings pond. However, the rules do require measures to control acid formation in the tailings pond and specify that the tailings be covered with a suitable composite cover designed to prevent water and air infiltration.

With respect to stated Commission policy and the proposed rules regarding chemical mining, (specifically, the technical feasibility of recovering and reusing the cyanide extractant employed in the recovery of gold and silver from ores and minerals in the state of Oregon) the Commission specifically asks:

"Do the requirements for removal and reuse of cyanide materially reduce the toxicity and long term potential for long-term cyanide and toxic metals release from mill tailings?

To answer this question, TRC has evaluated various process technologies specifically for technical potential, and to form a judgement of probable performance and demonstrated reliability in meeting the stated ODEQ intent. A summary of each technical review and evaluation is presented, including salient advantages and disadvantages. TRC then addresses specific issues of technical feasibility, toxicity reduction, reliability and level of certainty, and possible (viable) alternatives that may equally achieve the Commission policy.

The chemistry of cyanide is complex and many forms of cyanide can be present in mining solutions. TRC has elected not to provide an in depth review of cyanide chemistry due to the existence of extensive literature available [Ref 31, 32, 33, 34]. As appropriate, these literature sources are referenced throughout Section 3.0. TRC has attempted to summarize the major aspects, and to relate this material to the chemical mining rules as proposed by the State of Oregon. Discussion and supporting information is presented as part of the analysis for each aspect.

3.1 Technical Review and Evaluation

The cyanidation process for the extraction of gold has been in use for nearly one hundred years. The principal reasons for the widespread use of the process include: the simple concept; the ready availability of cyanide chemicals (which can be employed in relatively weak solutions) and, the strength and stability of the gold-cyanide complex. It is a well-established and efficient process, capable of extracting gold from otherwise very small concentrations, often with an efficiency of over 90% [Ref 30, 34]. Gold dissolves in a cyanide solution in the presence of oxygen. Typically, cyanide content, or concentration, is measured or quantified by the following designations:

- Free Cyanide: The term "free cyanide" refers to both cyanide (CN^- and hydrogen cyanide (HCN)) ions.

- Weak-Acid Dissociable Cyanide: Refers to metal cyanide complexes that may dissociate into free cyanide; also known as WAD.

- Total Cyanide: Reference to total cyanide will include all compounds that may be present in cyanidation solutions, including WAD and free cyanide, and those cyanide complexes that are not dissociated by weak acid [Ref 31].

In the absence of other metal cyanide complexes, as little as 100 ppm total cyanide (i.e. about 50 ppm free cyanide) can provide adequate gold dissolution rates. Silver is extracted in a similar manner but often requires stronger cyanide solutions and/or longer reaction times to achieve reasonable recovery efficiencies. Total cyanide solution concentrations for gold and silver extraction recovery typically range from 100 parts per million (ppm) to 2,000 ppm [Ref 32, 34].

Milling operations will generate a solid waste (tailing) that has little, if any, remaining economic mineral concentrations. The mill tailing materials typically contain only a minute fraction of the targeted economic mineral concentrations and are generally not intended to be reprocessed in the foreseeable future. Included in the mill tailing will be a certain percentage of process liquids (which may vary with technical processes employed) that remain from chemical processing operations. These liquids can be either "as received", or "diluted" (rinsed or treated to the extent necessary to meet specified end-point concentration limits such as the 30 ppm WAD standard stipulated in OAR 340-43-070(1)).

Operators must meet the specified concentration limit(s) through application of water (balance) management, in combination with treatment processes. One of the principal objectives of water management and tailings treatment is to develop the most economical process or combination of processes which will produce effluents compatible with, and protective of, the on-site environmental requirements, subsequent beneficial uses, and potentially impacted life forms associated with a receiving system. During the course of the mining operation the tailings wastewater characteristics can vary considerably due to changes in mineralization and ore geochemistry, the type(s) of metallurgical process(es) involved, the annual or daily precipitation, the size and type of mining and tailings (impoundment) disposal operations, and the concentrations of reagents required/utilized. The chosen process(es) must be reliable, yet flexible, to maintain a consistent quality of effluent throughout the life of the mine and, desirably through the closure and post closure periods.

The objectives of the design and planning of any recovery and reuse system should recognize the benefits associated with minimization of the volumes and flow rates of effluent streams. One practical approach toward achieving this is to treat the effluent stream and/or slurry waste as close to the point of origin and in as concentrated a form as possible, rather than attempting to manage a total flow of much greater volume and complexity during or after deposition.

Although similar metallurgical processes are employed over a wide range of mining operations, the resulting tailings wastewater characteristics vary widely; thus no single treatment approach is universally applicable. The selection of a treatment process or processes to achieve statutory or otherwise mandated effluent criteria is a site-specific exercise, and experience (as well as a high level of confidence) in the selected process is essential. Each treatment strategy, process, or combination of processes must also be evaluated for effectiveness in treating and removing residual solubilized metals.

3.1.1 Technical Feasibility of Removal and Reuse

TRC has interpreted the term "removal" to mean "physical isolation" from the liquid fraction of the tailings (in a form that may be reused). This is in contrast to "removal" by chemical alteration or destruction, which renders cyanide reuse as technically unachievable.

There are a limited number of physical and chemical techniques employed in the mining industry that can be considered as "removal and reuse" processes. Two of these methods (solid/liquid separation and acidification/volatization/reneutralization, respectively) have been determined as appropriate for achieving the stipulated "removal and reuse" requirement.

- PHYSICAL RECOVERY BY SOLID/LIQUID SEPARATION

Process solutions can be separated from mill tailings by thickening, clarifying or filtering the barren slurry (tailing) and returning the overflow (supernatant or filtrate liquors) directly to the milling process. The underflow (slurry or filter cake) will generally require additional treatment prior to discharge to the tailings impoundment. This additional treatment can include washing and/or chemical treatment to reduce the WAD cyanide content to specified levels. This process strategy technically conforms to the definition of "removal and reuse", and readily lends itself to follow-on treatment by "chemical oxidation" (or other means) as provided for in OAR 340-43-070(1).

There are a number of advantages realized through application of solid/liquid separation techniques. Solid/liquid separation reduces volume of solutions to be treated and stored. The physical recovery of process solutions may reduce the downstream treatment requirements and ease the management of the facility water balance. This may also allow the construction and management of a much smaller impoundment and storage facility. It also allows direct recovery of process solutions, which may reduce requirements for anti-scalants, alkalinity control and cyanide chemicals. It does not require pH adjustment for recovery. Therefore, HCN gases will not be produced, thereby improving plant safety. Added benefits include the flexibility gained through the fact that operations can be fully integrated into overall plant operations and equipment, materials and engineering expertise are readily available.

Also inherent in the process are a number of disadvantages, including that, under some site conditions, the process may be equipment and energy intensive and may require additional clarifying and filtration capacity to achieve adequate recoveries from process solutions. Also, high levels of flocculation chemicals may be required to achieve effective dewatering rates. In some instances, water balance conditions such as where there is a net inflow to the overall facility may complicate process strategies. Solid/liquid separation strategies do not directly remove WAD cyanide or heavy metals from the remaining, thickened slurries, so complexed metals cannot dissociate and precipitate. The process will generally require additional chemical treatment to achieve specified free and WAD cyanide levels. It is generally not a stand-alone process for cyanide recovery and reuse.

The solid/liquid separation process concept may be technically feasible when the slurries can be readily thickened or dewatered to yield sufficient additional process water to justify the recovery operations. However, the technical viability of this concept will require a site-specific examination of the process conditions and a determination of the physical and chemical process responses. These determinations can be made through carefully planned and executed test work. If, and when technically viable, the concept can provide the operator with considerable flexibility and be implemented with a high level of certainty.

This general concept is in practice at an operation in the Northwest and utilizes countercurrent washing and filtration in combination with what is known as the INCO SO_2 - O_2 process for cyanide destruction [Ref 35]. The concept is similar to the countercurrent decantation (CCD) processes already in use in gold mills and copper operations. It is likely that the underflow or filter cake, washed or unwashed, would require further treatment to meet the specified OAR 340-43-070(1) WAD standard and to reduce the potential for long-term cyanide and toxic metals release from the mill tailings.

The design and construction of such facilities is routine and there are several qualified companies in the United States that can provide turnkey services. These include, but should not be limited to, Fluor Daniel Wright; Bechtel; and, Davy McKee in California; Roberts and Schaefer in Salt Lake City; and Minproc, BEI, and United Engineers in Denver. There are numerous other smaller engineering houses that can provide capable design services. TRC notes that identification of the foregoing entities is intended solely to demonstrate availability of engineering and construction expertise, and in no way shall be construed as an endorsement of any specific technology or firm (entity).

Solid liquid separation equipment is readily available. The dewatering process would not require special materials of construction. Follow-on chemical treatment processes may require corrosion resistant materials, depending upon the selected treatment strategy.

- AVR PROCESSES (ACIDIFICATION/VOLATILIZATION/RENEUTRALIZATION)

Cyanide recovery by AVR chemical processing utilizes the volatility of hydrogen cyanide (HCN) (at a lowered pH) to strip free cyanide from solution or slurry and recover it in usable form. The original AVR processes were intended solely as a method of cyanide recovery from relatively clean barren solutions. Recent developments, however, have tended to focus upon the treatment of slurries [Ref 31, 36, 37].

AVR processes are affected by the concentrations of cyanide and the types of cyanide complexes that are present in the solutions. Performance is also dependent upon pH control, temperature, and slurry viscosity. The process requires high volumes of air to quickly and efficiently remove HCN from solution. Performance is also dependent upon proper equipment selection and design configurations. Designs must incorporate a means of controlling scaling and build-up of precipitated solids.

The AVR process is conducted in three stages. The first is known as acidification. This involves the lowering of process solution pH to below 8.5 with the use of concentrated mineral acid, typically sulfuric acid. Generally, a near neutral or slightly acidic solution is employed. The acidification step must be carried out in an enclosed environment to prevent escape of HCN gas. From the acidification stage, the acidified solution or slurry containing HCN is sent to the cyanide stripping or volatilization stage, which is usually conducted in packed towers. The volatilization system is sealed to prevent escape of HCN laden air and to allow efficient recovery of cyanide. HCN laden air is then withdrawn from the stripping tower and is reabsorbed into a caustic solution in a separate packed tower scrubber. The solution is recirculated within the scrubber until a specified concentration of cyanide is achieved, and is then returned to the process for reuse. Once the barren slurry or solution is free of recoverable cyanide, it is reneutralized. The pH is adjusted (for alkalinity) to precipitate the residual metals and to add buffering capacity to released solids. With the cyanide removed, the soluble metals are generally precipitated from solution as stable carbonates and hydroxides.

The advantages of the AVR process include the fact that, under favorable site conditions, the concentration of WAD cyanide in the barren or tailings impoundment water can be reduced below 30 ppm. Also, heavy metals and metal-cyanide complexes may be precipitated from solutions since the cyanide available for complexing has been removed. Also attractive is the fact that the process is applicable to barren leach solutions as well as tailings slurries, and the required reagents are readily available.

Conversely, a number of disadvantages are also associated with the AVR process, including the fact that the resulting HCN vapor is hazardous (requiring appropriate safety measures to be implemented and enforced); and additional treatment may be required to meet stringent effluent standards if there are higher levels of the more strongly bonded cyanide complexes. Higher initial levels of complexed cyanide may require adjustment of the pH to lower levels, and additional holding times to carry out the formation and removal of volatile HCN. If the cyanide solution is not re-used on-site, and reuse is mandated, transportation to another off-site user presents additional possible risk to the environment.

AVR technology is reasonably well defined, particularly for situations where it is applied to barren solutions. However, the necessary design conditions will be site specific and will depend on a thorough characterization of the anticipated quantities and qualities of process solutions. There are presently two commercial operations now using the patented CYANISORB (patent held by Cyprus Minerals Corp.) process in slurry treatment applications [Ref 36]. The first application at Cyprus' Golden Cross (Gold) Mine in New Zealand has been in operation since 1991. Nerco Mining,Inc. has recently commissioned a full scale AVR plant at their DeLamar (Silver) Mine [Ref 37] in Idaho. Each operation reports that performance is meeting design expectations. Both installations were preceded by extensive, site specific effluent and slurry laboratory and pilot plant testing.

There are several qualified companies in the United States that can design and construct AVR based process plants. However, for slurry applications these firms will generally require considerable direction from the operator (presumably functioning as licensee of the technology), and the patent holder. The process systems do not require special (other than corrosion resistant) plant equipment or materials of construction. All are readily available.

3.1.2 Toxicity Reduction Potential by Removal and Reuse of Cyanide and Cyanide Solutions

The principal reason for removing cyanide from gold mill effluents is to minimize the potential for harm to wildlife and to reduce the longer term risk of contamination of groundwater, surface water or soils through release of effluents to the environment. For this reason, the Commission has posed the question:

"Do the requirements for removal and reuse of cyanide materially reduce the toxicity and long term potential for long-term cyanide and toxic metals release from mill tailings?

A reduction in the relative concentrations of all forms of cyanide, but especially in free and WAD cyanide, will reduce the toxicity of mill tailings. The toxicity of cyanidation solutions is very complex and involves not only the toxic characteristics of the cyanide compounds but other constituents as well, including metals and degradation products [Ref 30, 31]. Other factors may aggravate toxicity conditions including insufficient dissolved oxygen, increased water temperatures, high or low pH conditions and salinity. The presence of zinc and copper in solution and dissolved ammonia may increase the toxic action of the solutions. Over the long term, once the source of the cyanide is eliminated, it can be considered to be a non-persistent chemical. Its action is reversible and living organisms have mechanisms capable of eliminating it [Ref 30].

While cyanide can eventually be toxic to all life forms, some aquatic microorganisms such as bacteria, algae and fungi can tolerate and metabolize cyanide at fairly elevated levels (up to 200 ppm) [Ref 32]. Higher aquatic organisms are less resistant. In fact, most species of fish are sensitive to levels considerably lower than the National Drinking Water Standard of 0.2 ppm. Therefore, solutions that must be released from a mining operation to the waters of the state will require additional and extensive treatment beyond the technical requirements of the ODEQ meet this standard for tailings effluents. Treatment technology to these levels cannot be achieved by recovery and reuse methods alone [Ref 30, 31, 32].

The use of WAD cyanide as a conservative control parameter provides an additional factor of safety since the control of the WAD cyanide to 30 ppm (or less) is usually representative of free cyanide levels well below 30 ppm.

Reuse of cyanide in and of itself would not reduce the immediate or long term toxicity potential of milling operation waste water system since the total cyanide in the system is not destroyed but is returned to the process. The recovery and reuse requirement would be expected to reduce the overall amount of cyanide chemical consumed over the life of the operation. Ultimately, however, whatever residual cyanide remains in the process solutions must be removed chemically prior to facility closure.

When employed to reduce cyanide levels, chemical destruction methods will tend to alter the cyanide species to less toxic nitrogen compounds (such as cyanate and ammonia) which are ultimately dissipated by natural processes. Reductions in cyanide levels in the liquids released to tailings will tend to accelerate the detoxification responses. The persistence of cyanide derived materials, therefore, will also tend to be transient [Ref 30, 31].

The selection of the optimum process or combination of processes necessary to reduce cyanide concentrations to a specified standard and to reduce the long term potential for cyanide and toxic metals release from the mill tailings must be consistent with site-specific criteria. Although there are similarities at various locations, each site is unique and evaluations must consider the chemistry of the ore and the resulting solutions, the local geological and hydrological conditions, the design and metallurgical objectives, as well as the response of the process solutions to various wastewater treatment options. The most important criterion that will provide immediate environmental benefit to the site is the removal of cyanide species from the process solutions impounded on site. It does not matter whether the cyanide is removed and reused or permanently altered to less harmful forms. There are many alternatives, and no one method is viable in all circumstances.

3.1.2.1 Technology Limitations

An assessment of the technical viability of treatment processes will generally require a site-specific test program to examine the appropriate process conditions and to determine the physical and chemical process responses. A proper assessment of the long term reliability of the selected treatment process, whether it is a recovery and reuse and/or chemical oxidation process, must consider the specific test results and the operating history of the selected process [Ref 30, 40, 41, 42].

In many cases the removal and reuse requirement may be consistent with the best and most appropriate tailings treatment process. However, when treating mill tailings slurries using the AVR process, favorable supporting test data must necessarily be weighed, at this time, without benefit of long term experience. In other instances, a chemical oxidation process may equally, or more effectively achieve the policy of the Commission. Several chemical destruction technologies, in fact, have extensively demonstrated and well documented operating histories [Ref 30, 31, 35, 42, 43]. The advantages and disadvantages of each method are well known and may often be evaluated with less site-specific testing. Chemical destruction processes are generally capable of reducing free and WAD cyanide to lower levels than those achievable through recovery and reuse processes.

Several different chemical oxidation methods are currently in use throughout the gold mining industry. Chemical methods within the plant are able to provide the operator with control over the content of WAD cyanide levels prior to impoundment as tailings or barren solutions or certainly prior to release as effluent. Chemical oxidation methods permanently alter the cyanide compounds, thus they are then unavailable for "reuse". The destruction methods described in this report are well established and provide a positive means of control.

The following methods generally have been applied as stand-alone processes. However, when appropriate, they may be used to supplement "recovery and reuse" technologies. These supplemental methods are briefly described below to enable their inclusion in the "Level of Certainty Analysis" (Section 3.1.3), and are further discussed in (Section 3.1.4) "Alternate Treatment Technologies".

- <u>Alkaline chlorination</u>: a process where the destruction of free and WAD cyanide is based on oxidation of the cyanide ion to cyanate (by the hypochlorite ion). Weak acid dissociable cyanide levels can be reduced to low levels in most applications and cyanate, ammonia, and thiocyanate can be further oxidized, if necessary. Iron cyanides are not usually decomposed but metal concentrations in solution can be reduced to very low levels by precipitation. Once the cyanide is oxidized the metals precipitate as insoluble hydroxides [Ref 30, 31, 32].

  The use of chlorine and hypochlorite for the treatment of barren cyanide solutions is the most highly developed of all the available cyanide destruction methods. Operations are simple, reliable and flexible, and they may be easily controlled and automated.

- <u>Destruction by Sulfur Dioxide</u>: can be accomplished through either of two commercial processes that are characterized by the oxidation of cyanide to cyanate using sulfur dioxide or mixtures of sulfur dioxide and air [Ref 30, 31]. The processes reportedly are able to reduce total cyanide and metals to exceptionally low levels. Free and weak acid dissociable cyanide species are chemically removed by oxidation to cyanate. Iron cyanide complexes are reduced and precipitated as insoluble ferrocyanide salts. After the metal cyanide complexes have been precipitated, a ferric sulfate solution may be added to precipitate the remaining heavy metals. The cyanide is chemically destroyed and cannot be recovered for reuse. Thiocyanate, cyanate and ammonia are not further oxidized by the process [Ref 30, 31, 32].

- Hydrogen Peroxidation: encompasses two commercial processes that utilize hydrogen peroxide to destroy free cyanide and WAD cyanide. Hydrogen peroxide, in the presence of copper oxidizes the free cyanide to cyanate. WAD cyanide is also oxidized to cyanate. The metals released during the oxidation are precipitated as hydroxides. The iron cyanide complexes are combined with free copper and precipitated as insoluble ferrocyanide salts. Heavy metals are also effectively precipitated. The resulting thiocyanate, cyanate and ammonia complexes are not readily or rapidly further oxidized in the process.

  The process has been successfully applied on a wide variety of process solutions, including slurries. Reductions in total cyanide concentrations to the limits established by the ODEQ have been demonstrated. The method is well suited as either a primary destruction method or as a supplemental method, to be employed as site conditions require.

3.1.3 Level of Certainty Analysis

The level of certainty analysis is intended to be a summary statement on the reliability of the technical assessment of the projected performance of a system or technology. The level of certainty depends greatly upon past performance (as measured by the experience of the designer, operator and the history of operating practices that utilize the specific techniques and/or technology). The level of certainty in the selection of a process is directly related to the evaluation of site specific performance data, as generated by testing parameters and results. The level of certainty is enhanced by the application of conservative design criteria, operator training/expertise, and operating and maintenance practices.

3.1.3.1 Cyanide Removal By Solid/Liquid Separation

Cyanide removal by solid/liquid separation is a positive physical removal system. Reduction in the volumes of slurry released to a tailings impoundment will have a beneficial effect on reducing avian mortality by potentially reducing the area and extent of the liquid pool in the tailings impoundment. When supported by testwork, scale-up is readily and reliably achieved. However, changes in ore characteristics, such as the generation of fines, or clays, by alteration of certain minerals, may make thickening or filtration more difficult, considerably lowering the level of confidence in this technology. Testwork, therefore, must produce a thorough understanding of the expected ore characteristics.

3.1.3.2 AVR Processes

The recovery of cyanide by AVR processes will provide a positive benefit through reduction of the concentrations of free and WAD cyanide released to the impoundments. The process will depend upon the ore characteristics and the required degree of acidification to dissociate the weakly complexed (WAD) cyanides, as well as the viscosity and temperature of the slurries and solutions. Adequately planned testwork will alleviate some degree of technical concern and raise the level of confidence. However, the experience to date with AVR systems on slurries is limited.

3.1.3.3 Alkaline Chlorination

Alkaline chlorination is a well known and well understood technology. However, process specific metallurgical testing is recommended. Scale up requirements are well understood and the technology may be implemented with a high level of confidence. In most cases, alkaline chlorination methods can be implemented to reduce free and WAD cyanide to the levels established by the ODEQ. However, high reagent consumption and the potential for toxicity due to chlorine (which requires still more residual treatment) has reduced the operator preference for this method.

3.1.3.4 Destruction by Sulfur Dioxide

Cyanide destruction by sulfur dioxide is a well demonstrated technology. Process specific metallurgical testing is necessary but scale-up requirements are well understood and the technology may be implemented with a high level of confidence. The process is less sensitive to variations in ore characteristics. The process has been successfully applied in many locations to reduce total cyanide to levels well below the ODEQ standard. Soluble metals are effectively reduced as well. The INCO process has become the most widely utilized cyanide destruction process in the gold industry.

3.1.3.5 Hydrogen Peroxide Destruction Processes

Cyanide destruction by hydrogen peroxide is a well demonstrated technology. Process specific metallurgical testing is necessary from which scale up requirements are well understood. The technology may be implemented with a high level of confidence based upon proper review and interpretation of site specific testing. The peroxide process is relatively simple to implement. H_2O_2 processes have been successful for both continuous operations and for short-term applications such as rinsing and final detoxification procedures prior to closure.

3.1.4 Alternate Treatment Technologies

There are several technologies or combinations of technologies that have the potential to achieve the requirements of the ODEQ. As stand-alone technologies, each may achieve the standards set out for cyanide reduction. Combining methods, where both have been shown as capable of meeting ODEQ standards, may in many instances create a redundancy that does not materially add to environmental protection. As discussed previously, successful universal application of any single process technology is unlikely. Likewise, the designation of a single control technology may not best meet the stated policy of the Commission. As such, flexibility to select the best option(s) to comply with specified concentration standards, irrespective of whether cyanide may be reused or destroyed, may represent a more realistic approach.

Alternate treatment technologies that may meet the requirements of the DEQ are presented below. Brief introductions to these methods were presented previously.

3.1.4.1 Alkaline Chlorination

As discussed previously, the alkaline chlorination process for the destruction of free and WAD cyanide is based on the principle of oxidation of cyanide to cyanate (by the hypochlorite ion) at pH values in the range of 10 to 11. Hypochlorite ion may be provided by the use of either liquid chlorine or solid calcium hypochlorite. Additional lime or caustic is required to maintain a high pH to prevent undesirable side reactions. Weakly complexed metal cyanides behave similarly, but are oxidized more slowly. Once oxidized, the metals precipitate as insoluble hydroxides. Ferrocyanide is not directly affected by the treatment but may precipitate by forming insoluble salts heavy metals [Ref 30, 31, 32].

A reduction in the levels of all forms of cyanide, but especially in free and WAD cyanide, will reduce the toxicity of mill tailings. The cyanates formed in this process are considerably less toxic than the corresponding cyanides. Alkaline chlorination may be considered if recovery and reuse is unable to achieve the desired WAD cyanide concentrations.

The use of chlorine or hypochlorite for the treatment of barren cyanide solutions is the most highly developed of all the available cyanide destruction methods. Operations are simple, reliable and flexible, and they may be easily controlled and automated. Advantages include the following:

- Weak acid dissociable cyanide levels can be reduced to 30 ppm in most applications;
- Cyanate, ammonia, and thiocyanate can be further oxidized if necessary;
- Toxic metal concentrations can be reduced to very low levels;
- Alkaline chlorination is a well understood process;
- Chlorination reagents are readily available; and,
- Equipment, materials, and design expertise are readily available.

Likewise, a number of disadvantages are inherent in the process, including:

- Reagent consumption may be excessive if the solid phase contains excessive amounts of reactive sulfides;
- Cyanide is not recovered, but is chemically destroyed;
- Reagent costs are also high if thiocyanate is present or if complete destruction of cyanate and thiocyanate is required;
- An additional treatment step may be necessary to dissipate residual chlorine;
- Careful control of pH is necessary to prevent the release of highly toxic cyanogen chloride gas; and,
- Iron cyanides are not usually decomposed.

The technical definition and understanding of alkaline chlorination processes is well documented [Ref 30, 31, 42]. Like all processes, the necessary design criteria will be process specific. The process removes WAD cyanide by chemical destruction, thus cyanide cannot be recovered for reuse. It is however, technically feasible to utilize the process in combination with removal and reuse technology or as a stand alone cyanide destruction process.

Alkaline chlorination has been successfully applied at numerous mining and chemical plating operations for cyanide destruction. There are a number of applications in Canada [Ref 30, 31], and Battle Mountain Gold now utilizes alkaline chlorination on slurries at the Fortitude Mine in Nevada [Ref 44]. However, the industry trend is toward other, more efficient cyanide destruction technologies [Ref 31, 35].

There are several qualified companies in the United States that can design and construct alkaline chlorination facilities, including those previously cited (Section 3.1.1). The process does not require exotic plant and equipment but will require certain materials of construction to be resistant to chlorides. However, these materials are readily available.

3.1.4.2 Destruction by Sulfur Dioxide

Also discussed previously, the two commercial sulfur dioxide destruction processes are commonly referred to as the INCO SO_2/Air process, and the Noranda process, respectively. Both are predicated upon the concept of oxidation of cyanide to cyanate (using sulfur dioxide or mixtures of sulfur dioxide and air), and are reportedly able to reduce total cyanide and metals to exceptionally low levels [Ref 30, 31, 42, 41].

The INCO SO_2/air process for total cyanide removal is based on oxidation of cyanide to cyanate using mixtures of SO_2 and O_2 as the oxidizing agents (in the presence of soluble copper) in a controlled pH range. The SO_2 can be supplied as a gas, as sulfurous acid, or as a soluble sulfite or bisulfite. The O_2 can be supplied by air. The process will require the addition of lime to maintain the proper alkalinity. The process developed by INCO now has a lengthy experience list and is comparable to AVR processes in technical and economic performance. Reductions of WAD cyanide to very low levels have been consistently demonstrated.

The Noranda process utilizes sulfur dioxide (which is fed directly into the process) to lower the pH to the prescribed range (usually between 7 and 9) and a copper sulfate solution is then added to reduce the total cyanide level. Once the metal cyanide complexes have been removed by precipitation, a ferric sulfate solution may be added to remove the remaining heavy metals.

Free and weak acid dissociable cyanide are removed by oxidation to cyanate. Iron cyanide complexes are reduced and precipitated as insoluble ferrocyanide salts. Heavy metals are also effectively removed. The process has been successfully applied on a wide variety of process solutions, including slurries. It has been demonstrated that cyanide concentrations may be consistently reduced to levels below the limits established by the ODEQ.

Treatment conditions, final effluent quality and process control strategies will vary according to the specific composition of the process liquids and the reactivity of the solids. The following advantages and disadvantages are reported [Ref 30, 31] for the sulfur dioxide based processes.

Destruction of cyanide in mill tailing effluents by sulfur dioxide offers several advantages, including the following:

- Process is proven and well understood, and technical support is available from patent holders and licensees;
- Removes total cyanide to low levels (less than 30 ppm);
- Removes metals and iron cyanides to low levels;
- Can be applied to solutions and slurries;
- Process is flexible and can be automated;
- Reagents are readily available;
- Reactions are rapid and no toxic gaseous intermediates are formed; and,
- Equipment, materials, and design expertise are readily available.

Likewise, a number of disadvantages are inherent in sulfur dioxide cyanide destruction, including:

- Reagent requirements may be high;

- Cyanide is not recovered, but is chemically destroyed;
- Thiocyanate, cyanate and ammonia are not oxidized further;
- Each effluent must be tested for site specific design and scale up criteria; and,
- Processes are patented.

Sulfur dioxide processes have been widely accepted and successfully utilized in recent years, however, the necessary design criteria are generally process and site-specific. The process(es) remove cyanide by chemical destruction and precipitation, thus the cyanide cannot be recovered for reuse. It is technically feasible to utilize the process in combination with removal and reuse technology or as a stand alone cyanide removal process.

Of note, the INCO process is the most widely utilized cyanide destruction process in the gold industry today. Successful installations include Echo Bay's Cove-McCoy and Kettle River Operations among over 30 licensed applications since 1985 [Ref 35].

There are several qualified companies in the United States that can design and construct the facilities. Plant and equipment will require corrosion protection but the necessary materials of construction are readily available.

3.1.4.3 Hydrogen Peroxide Destruction Processes

There are two commercial processes (known as the Kastone and Degussa processes, respectively) that utilize hydrogen peroxide to destroy free cyanide and WAD cyanide. The Kastone process was originally proposed and patented by duPont. The process uses a solution of hydrogen peroxide (containing a small amount of formaldehyde and copper) and was first utilized on a trial basis on gold mill effluent in 1981. The process developed by Degussa Corporation applies hydrogen peroxide with small amounts of copper but does not require formaldehyde [Ref 40].

Hydrogen peroxide, in the presence of copper, oxidizes the free cyanide to cyanate. Weak acid dissociable cyanide is also oxidized to cyanate. While metals released during the oxidation are precipitated as hydroxides, iron cyanide complexes are combined with free copper and precipitated as insoluble ferrocyanide salts. Heavy metals are also effectively removed. The process has been successfully applied on a wide variety of process solutions, including slurries. Total cyanide concentrations have been reduced in most instances to levels below the limits established by the ODEQ.

The reduction in the levels of all forms of cyanide results in a corresponding reduction of toxicity in the mill tailings. This is due to the fact that the cyanates formed in this process are considerably less toxic than the corresponding cyanides. These compounds will slowly hydrolyze and dissipate in the tailings impoundment. The process introduces no new chemicals with adverse environmental concerns. Treatment conditions, final effluent quality and process control strategies will vary according to the specific composition of the process liquids and the reactivity of the solids.

The following advantages [Ref30, 31] are reported for hydrogen peroxide destruction processes:

- The process is proven and well understood and technical support is available from patent holders and licensees;
- Removes total cyanide to low levels (generally less than 30 ppm);
- Removes metals and iron cyanides to low levels;
- Can be applied to solutions and slurries;
- Process is flexible and can be automated;
- Reagents are readily available;
- Reactions are rapid and no toxic gaseous intermediates are formed; and,
- Equipment, materials, and design expertise are readily available.

Conversely, a number of disadvantages have been identified for the hydrogen peroxide destruction processes:

- Reagent requirements may be high;
- Cyanide is not recovered, but is chemically destroyed;
- Close control of pH may be required;
- Thiocyanate, cyanate and ammonia are not oxidized further; and,
- Each tailing effluent stream must be tested for site specific design and scale up criteria.

Hydrogen peroxide processes have been successfully utilized in recent years. However, the necessary design criteria will be process specific. The process removes cyanide by chemical destruction and precipitation, thus the cyanide cannot be recovered for reuse. It is technically feasible to utilize the process either as a secondary treatment stage when employed in combination with removal and reuse technology, or, as a stand-alone cyanide destruction process.

Destruction of cyanides by oxidation with hydrogen peroxide has been demonstrated at over twenty operations in the United States, Canada and elsewhere. The Barrick Goldstrike operation has utilized peroxide to reduce free and WAD cyanide levels to 20 ppm [Ref 43].

There are several qualified companies in the United States that can design and construct hydrogen peroxidation facilities. The process does not require exotic plant and equipment.

3.1.4.4 Reduction by Ferrous Sulfate

Ferrous sulfate (or zinc ferrous sulfate) can be used to reduce the levels of free and WAD cyanide in the liquid portions of the tailings. Ferrous sulfate readiy forms complexes with free cyanide and with WAD cyanides if the pH is sufficiently lowered to allow the iron to replace other, less strongly associated cations. Although the ferrous and ferric cyanide complexes are precipitated, they can be decomposed by ultraviolet light in the shallow liquid pool areas of the tailings impoundment. The most prudent process strategy is to first reduce the free and WAD cyanide by removal and reuse or by outright destruction before introducing additional iron into the process.

Ferrous sulfate represents a potential option for emergency treatment of cyanide solutions in the event of a spill or equipment breakdown. It may also be suitable for final treatment of tailings or solutions once recovery and reuse methods have been completed.

3.1.4.5 Natural Degradation

Natural degradation occurs as a result of the interaction of several processes of cyanide decay such as volatilization, hydrolysis, photodegradation, dissociation, chemical and bacteriological oxidation and precipitation. New operations have the opportunity to develop and design impoundment systems to optimize, or capitalize upon the treatment effects offered through natural degradation processes. Physical and chemical phenomena can be used advantageously in the reduction of effluent toxicity and in the management of process solutions to optimize chemical usage and water management practices.

Volatilization, and dissociation, of the metal-cyanide complexes are the main mechanisms responsible for the natural degradation of cyanide in gold mill effluents. Volatilization causes a rapid, initial loss of cyanide, while dissociation controls the rate of degradation (particularly in the latter phases of natural degradation). Since initial concentrations are minor, and rapid dispersal occurs, air quality impacts are insignificant. If the WAD cyanide is removed prior to discharge, a shallow pooling impoundment design may optimize the ultimate detoxification of cyanidation process solutions. Research into the phenomena of natural degradation is limited, but the method is promising and the development of a clear understanding of the process will provide substantial benefit in protecting the environment from the release of toxic solutions to the environment.

Natural degradation would not be considered an effective stand-alone technology, however it can be effectively utilized as an added mechanism contributing to the long term reliability of technologies in minimizing the risk to the environment.

4.0 QUESTIONS ON THE CLOSURE OF HEAP LEACH AND TAILINGS FACILITIES

This section of the mining advice report addresses the closure of heap leach and tailings facilities, with regard to utilizing the following processes: 1) Detoxification; 2) Covering; and 3) Detoxification and Covering utilized together. Evaluations of these processes were conducted in order to address the following four closure questions with regard to both heap leach facilities and tailings impoundments:

Question 1: *Are detoxification and covering as prescribed in the EQC policy, technically feasible?*

Question 2: *Do detoxification and covering evaluated separately and together, material reduce the likelihood of a release of toxic chemicals and metals to the environment?*

Question 3: *What is the level of certainty assigned to each of the above answers Questions 2 and 3?*

Question 4: *Are there other technologies which can equally or more effectively achieve the EQC policy?*

TRC approached these questions utilizing published information and technical data available from sources including the U.S. EPA, the Society of Mining Engineers, etc. In the following report subsections, discussions of the evaluations are presented for each of the four questions.

4.1 Technical Feasibility of Detoxification and/or Cover Systems for Heap Leach Facilities

4.1.1 Detoxification of Heap Leach Facilities

Cyanide degradation and attenuation in a heap can be achieved by individual or combined application of rinsing, chemical treatment, or natural degradation reactions. The upper portions of the heap provide an oxidizing environment, due to the high permeability of the heap itself (an essential requirement for the extraction of gold and silver) ensuring a reasonable flow of air. Oxidation will contribute to pH reduction and the formation of HCN; volatilization will ensue. These reactions will be supplemented by oxidation by biological activity within the heap.

Cyanidation processes generally employ a pH of 10.5 or greater. Following decommissioning and abandonment, there will be a gradual decrease in pH within the heap as a result of rinsing, natural dilution and geochemical interactions with air, water and the various solid materials within the spent ore. Hydrolysis reactions will develop (independent of pH) and can occur under oxidizing and reducing conditions. The oxidation or chemical alteration of certain minerals will produce newly created clay surfaces that will also absorb chemical and metal ions from solution. It is technically feasible to reduce the WAD cyanide levels within the heaps to 0.5 ppm or less through rinse/rest cycles and chemical oxidation, minimizing post-closure toxicity concerns.

4.1.2 Cover/Closure of Heap Leach Facilities

The feasibility of covering heap leach facilities, at closure, was examined with regard to various considerations including those engineering related considerations and the long term closure effects. The covering of heap leach facilities may be accomplished by utilizing either earthen materials such as clay caps, or synthetic materials such as geomembrane covers. In general, covering the top of the heap with either material should be relatively straight forward, provided a QA/QC program is carried out during the construction. Covering of the side slopes of a heap, is often more difficult, due to their steepness, which are generally on the order of 2:1 (horizontal to vertical). As a result, limitations related to equipment used to place and adequately compact earthen cover materials may present difficulties. This problem may be addressed by placing the earthen cover materials at a milder slope, which could require regrading of the heap, or use of additional cover materials or fill materials to flatten the side slopes. The utilization of synthetic cover materials on the heap side slopes should be relatively uneventful, provided sufficient anchorage is provided to retard slippage of the material and that the material is relatively resistant to ultraviolet radiation and other environmental conditions. The use of cushioning materials between the liner and the ore may be indicated, if the underlying ore has the potential to puncture or otherwise damage the synthetic cover materials. Earthen cover materials should be covered with a topsoil or other material to retard the loss of moisture from the cover, thus reducing the likelihood of desiccation cracking. Synthetic cover materials may similarly be covered, to reduce the possibility of damage from site conditions, or deterioration effects resulting from environmental conditions.

The establishment of vegetative stands of growth may be expected to occur through either the earthen cover materials or synthetic cover materials. As a consequence, the amount of infiltration capable of percolating into the heap from precipitation and snowmelt events will increase. Also, the presence of burrowing animals can also increase the overall amount of infiltration into the heap. In general, the lower the permeability and the greater the compaction for earthen covers, the less the cover will be affected by these influences, provided post closure programs are subscribed to with regard to vegetation and animal control. It has been suggested that the utilization of layers of cobbles may be somewhat successful in deterring animal burrowing and root growth [Ref 1].

The stability of the heap may be enhanced to some degree by utilization of cover materials, as a result of the reduction in precipitation able to infiltrate the ore. This is particularly true where the facility is not provided with adequate drainage or the post-closure water balance indicates a net fluid buildup in excess of the evaporation potential of the undrained facility.

4.2 Technical Feasibility of Detoxification and/or Cover Systems for Tailing Facilities

4.2.1 Detoxification of Tailings Impoundment Facilities

Tailings detoxification is technically feasible and the processes are well understood. (Refer to Section 3.0 of this document.) Cyanide recovery and chemical treatment methods are intended to reduce the level of weak acid dissociable cyanide that is released to tailings impoundments. These treatment methods generally involve altering of the pH of the solutions, which may affect the solubility of certain heavy metals. Detoxification of tailings prior to disposal presents a positive and measurable control effort. In addition, the tailings impoundment(s) will function as a treatment unit (over the long term, due to natural degradation processes); as such, the levels of soluble cyanide and metals will tend to further dissipate over time.

Cyanidation processes are operated under highly alkaline conditions (at a pH greater than 10.5) to prevent the loss of HCN by volatilization and to protect the working environment of the operator. This pH would be reduced by the active application of a cyanide recovery system as well as through utilization of various oxidation methods. The solutions in tailings ponds would tend to drift toward a neutral pH range due to dilution, absorption of CO_2 from the atmosphere, and the possible generation of acids as a result of oxidation of the sulfide minerals. As the pH is lowered, some of the metal-cyanide complexes will dissociate into free cyanide. The tightly bound iron cyanide complexes will also be decomposed photochemically (naturally degraded through exposure to sunlight). This effect can be enhanced by the design of the tailings impoundment to maximize mixing and exposure to air and sunlight. Molecular HCN will dissipate (by volatilization) and the total cyanide concentration of the pond will be permanently lowered.

The nature of the solids generated during processing is important to these processes. Since rocks and soils normally contain free (or excess) cations, absorption of cyanide as metal cyanide complexes will be favored. WAD cyanide may be adsorbed on organic materials (including activated carbon), clays, feldspars and metal oxides. These surface effects have been shown to provide a significant contribution to cyanide reduction in tailings systems. As a result of these combined natural chemical processes, the total cyanide is often eventually reduced to levels below the proposed rule treatment standard (< 30 ppm) for tailings.

The levels of soluble metals are also reduced. Indications [Ref 30, 31] are that the solids' mass in tailings or heaps interacts with the solutions and that the cyanide appears to be permanently absorbed or converted (under aerobic and anaerobic conditions) to other nitrogen compounds. The proportions of free cyanide to total cyanide are dramatically decreased, indicating formation of metallic complexes and precipitation. Therefore, in the absence of acid generating sulfide minerals, cyanide mill tailings will tend toward chemical stabilization and the mobilization of heavy minerals will be arrested.

4.2.2 Cover/Closure of Tailings Facilities

As with the heap leach facility, the cover of a tailings facility may be carried out similarly with the use of either earthen or synthetic cover materials. However, it should be noted that for wet or undrained tailings dam facilities, it may not be possible to cover the facility until after it has been closed for many years. This is due to the potential for settlement of the unconsolidated tails, in addition to their lack of shear strength to support construction equipment. The evaporation of supernatant, pore fluids and air drying of the upper tailings horizon will eventually contribute to consolidation to some degree, with the deeper deposits being less prone to drying and more prone to consolidation unless provisions are made for direct drainage of these bottom deposits. The utilization of drained tailings deposition techniques may have beneficial effects on reducing the time period from closure to the initiation of cover operations but will depend largely on the physical and chemical properties of the tails and their ability to be drained, as well as the extent, effectiveness and layout of the drains, and the resulting density stratification of the tails.

Once the tails have achieved sufficient strength and their potential for consolidation settlement has been reduced, covering can generally be effectively facilitated with the use of earthen or synthetic cover materials, provided a QA/QC program is properly carried out. Covering the sideslopes of the impoundment with earthen cover materials may pose some construction difficulties and may require overfill and cut back techniques to be utilized, and/or the use of adequately anchored synthetic materials.

The use of cushioning materials between the tailings and synthetic cover materials, (when utilized) may be indicated if there is a potential for occurrence of puncture or other damage to the cover. The loss of moisture from earthen cover materials should be minimized by cover with topsoil or other materials to prevent the occurrence of desiccation cracking. Synthetic cover materials should be protected as well from damage potentially related to site conditions or deterioration effects resulting from environmental conditions.

Vegetative and animal control plans should be implemented to minimize the effects that root growth and burrowing animals will have on increasing the overall infiltration through either of the cover systems selected.

The stability of the tailings facility during the post closure period may be enhanced with the construction of a cover system, since the potential for long term buildup of precipitation water in the tails should be reduced (as should the pore pressures). This would hold particularly true in the event that there are no provisions to drain the facility after closure, and if the post closure water balance indicates a buildup of fluids in excess of the evaporation potential of the undrained facility.

4.3 Material Reduction of Likelihood of a Release to the Environment (Heap Leach Facilities)

4.3.1 Effects of Detoxification (Only) for Heap Leach Facilities

Literature reporting operating experience at two heap leach facilities [Ref] indicates that WAD cyanide can be reduced to 0.5 ppm in most instances, and lower in some instances. Similar reductions in soluble metals has also been reported. As the closed heaps "age", it is anticipated by the operators that the total and WAD cyanide levels will be stabilized at permanently low levels. In the absence of acid generating minerals, heavy metals are not expected to be mobilized [Ref 30, 31, 32] and concentrations are expected to remain at low levels.

4.3.2 Effects of Closure/Cover (Only) for Heap Leach Facilities

From a chemistry standpoint, covering of the facilities without prior detoxification would reduce the oxidation potential of the free cyanide present within the ore. As a result, the free cyanide ion would be more susceptible to hydrolysis, wherein the free cyanide ion would react with water and result in the generation of hydrogen cyanide. This reaction is very pH sensitive, but the presence of hydrogen cyanide in the heap would be less desirable than cyanide in its oxidized state (as cyanate or cyanate salts). Hydrogen cyanide has a high vapor pressure and readily volatilizes into a gaseous state, which would be undesirable unless venting through the cover was provided. Covering of the heap would also reduce the dilution of the cyanide present within the heap. The effect of covering the facility would generally be beneficial, if fluid buildup is in excess of the evaporation potential. The mobilization of metals, if anticipated to occur, would also be reduced. Accordingly, the cover would have a beneficial effect for heaps in which the ore possesses potential acid generating constituents such as sulfide minerals (e.g., pyrite). The reduced oxidation potential or reduction of the potential for additional hydrolysis of the sulfides would greatly contribute to a reduction in acid generating potential, particularly for those acids generated in the form of hydrogen sulfide.

However, the reduction in oxidation potential of the cyanide would cause the natural degradation of the free cyanide resulting from evaporation of the leachate and its subjection to ultraviolet degradation to be deterred as a result of covering the heap.

The stability of the facility may be enhanced by covering, since the potential for buildup of the fluid level in the heap would be reduced, particularly if the post closure water balance indicates a buildup of fluid in excess of the evaporation potential of the facility. In addition, the stability may also be enhanced, since the potential for erosion and sloughing of the heaped ore may be reduced with the construction of a cover system. The potential for wind-induced erosion of the heap may be reduced through covering, positively contributing to the ambient air quality of the site and surrounding environment.

4.3.3 Effects of Combined Detoxification and Closure/Cover - Heap Leach Facilities

Detoxification of a heap will ultimately reduce free and WAD cyanide to concentrations as low as 0.5 ppm in the short term, and as low as 0.2 ppm over the long term, and will tend to stabilize metal release. In such situations, an engineered cover designed to exclude air and water may provide no additional benefit and may in fact be deleterious to the detoxification attributes. However, heaps tend to be more porous and the need to exclude water and air (when acid generating materials are a concern) may require a more thorough analysis to determine when a cover is unwarranted and/or of questionable benefit.

Covering of the heap leach facilities after detoxification would have the effect of reducing the infiltration potential for precipitation into the heap as well as the availability of oxygen. In general, the chemistry of the spent ore would not be greatly affected, with or without the inclusion of cover, after successful detoxification of the spent ore, provided the spent ore does not contain metals or acid generating constituents such as sulfides. In these cases covering of the facilities may be desirable as a method of reducing the effects of acid generating potential or metals mobility within the spent ore, particularly if the post closure water balance shows fluid buildup in excess of the evaporation potential.

After detoxification has been successfully completed at heap leach facilities (with the exception of those with the potential for acid generation) the need for cover would generally not be warranted, if it can be demonstrated that the evaporation potential exceeds the anticipated fluid buildup within the facility. This would ensure that the build up of fluid levels within the heap would not occur and that the stability would not be affected. Spent ore which exhibits concerns related to erosion potential from precipitation or wind influences, could be addressed by investigating other methods to reduce this potential. These may include compaction of the surface materials, utilization of stabilization admixtures, or implementation of a vegetation plan.

4.4 Material Reduction of Likelihood of a Release to the Environment (Tailings Facilities)

4.4.1 Effects of Detoxification (Only) for Tailings Impoundment Facilities

In the absence of acid generating minerals, a tailings impoundment that has been receiving detoxified solutions will tend to stabilize. Metals that were solubilized in the milling process will precipitate, tending not to remobilize. As solutions percolate through the impoundment, natural attenuation and adsorption occurs. Ponds with surface water concentrations of 200 ppm total cyanide have been correlated [Ref 31] with solution concentrations of 2 or 3 ppm within the solids portion of the tailings, indicating efficient attenuation of the solution toxicity. With the deposition of lower concentration solutions, correspondingly lower levels within the tailings mass may be expected.

4.4.2 Effects of Closure/Cover (Only) for Tailings Impoundment Facilities

The effects of covering the tailings facilities without detoxification are essentially the same as those discussed for the heap leach facilities. However, due to the generally wetter state of the tailings (as compared to spent ore remaining in closed heap) it would be expected that the reduction of the oxidation potential of the free cyanide present within the tails would have a greater influence with regard to generating hydrogen cyanide. In addition, the reduction of the dilution potential of the cyanide (as a result of covering) would result in the presence of higher concentrations of hydrogen cyanide which could potentially be dispersed through the liner with seepage. This would be of particular concern in wet tailings facilities. The covering of larger facilities (of great surface area) would result in a loss of beneficial natural degradation processes.

On a comparative basis, covering of the tailings facilities would generally have a more beneficial effect (than would covering of heap leach facilities) on reducing the tails' erosion potential from precipitation and wind. This is due to the tails finer gradation, in comparison to the coarse spent ore typically remaining in heaps.

4.4.3 Effects of Combined Detoxification and Closure/Cover - Tailings Facilities

Once detoxified, and if the risk of metal release through acid generation is minimal, an engineered cover designed to exclude air and water may provide little, if any, quantifiable benefit with respect to prevention of toxicity release.

After detoxification of a tailings facility has been successfully carried out, the need to cover the facility would generally not be warranted (from the standpoint of contaminant containment), provided that the heavy metals species have been removed from the system during the cyanide neutralization process and that the tails do not possess the potential for acid generation. In some cases drainage of the facility could be implemented, particularly in net precipitation environments (where precipitation exceeds the evaporation) and where the potential for long term build up of fluids in the facility exists, particularly during a sequence of wet years. By maintaining the facility in an uncovered state, the potential for desirable attributes such as allowing the tails to dry out and densify would be enhanced over the long term as compared to the covered state, where drying and densification may never occur unless drainage provisions are implemented.

Other erosion control measures (in lieu of cover) could be implemented, including broadcast planting of a vegetative cover compatible with the tailings. Other erosion control measures, including covering, may not be able to be implemented for a substantial period of time, due to the lack of the tailing's shear strength, and consolidation potential, which will generally preclude heavy equipment operations until the tails have been able to consolidate and densify. In the event that covering of the facility is necessitated for some reason, the utilization of synthetic materials for cover may be feasible, provided that the potential for the tails settlement and the damage to the synthetic cover, is considered. Synthetic materials can generally be placed without the utilization of heavy equipment operations. In addition, floating covers may sometimes be considered as an alternative covering method [Ref 46].

4.5 Level of Certainty Evaluation

4.5.1 Detoxification on a Stand-Alone Basis

For mill tailings, in the absence of high levels of acid generating minerals, detoxification methods are expected to achieve the proposed rule requirement for reducing free and WAD cyanide to levels below 30 ppm. However, to achieve the drinking water standard of 0.2 ppm may require additional treatment prior to release of solutions from the tailings impoundment. If the liquid portions of the tailings are to be released, then additional chemical treatment will be required. Any of the chemical destruction methods described above may be applied, as appropriate, to achieve the required levels. These methods may be applied with a high level of confidence. Alkaline chlorination is extremely effective for final treatment, but may require an additional dechlorination step prior to releasing process water.

With heap leaching facilities, the rinsing, chemical treatment and natural degradation processes may be applied with a reasonably high level of confidence to achieve free and WAD cyanide levels of 0.5 ppm. In some cases, the drinking water standards can be achieved prior to release to the environment. Although, theoretically, evaporation may concentrate the cyanide complexes remaining in solution, as a practical matter, other soluble salts will begin to precipitate and will co-precipitate cyanides and toxic metals. Also, where evaporation is substantial it is unlikely that any solution will remain for discharge to the environment.

4.5.2 Closure/Cover on a Stand-Alone Basis

The level of certainty that would be expected to be achieved as a result of covering the heap leach facilities at closure (without prior detoxification) would be low. This is due to the fact that heap chemistry would not have the benefit of natural degradation processes that occur as a result of dilution and oxidation of the free cyanide and cyanide complexes. In addition, the buildup of cyanide gas would also be a concern, without provision for adequate venting. In cases where potential for acid generation or solubilization of heavy metals exists, covering of the heap may be necessary. This may also be true where containment of the contaminant by the liner system is deemed questionable, or where the post closure water balance indicates lack of sufficient capacity to contain fluid buildup. However, it should be noted that in those cases where covering is utilized, leaks through the cover will still occur due to defects introduced through growth of plant roots and actions of burrowing animals. As a result, the level of certainty for the cover scenario would still be considered low for this reason alone.

The level of certainty expected with the covering of tailings facilities (without detoxification) would be low. This would result from the fact that the beneficial natural degradation processes including dilution and oxidation of the free cyanide would be prevented from occurring. Also, the buildup of cyanide gas may also be a concern, without adequate ventilation provisions. In the cases where the potential for sulfide generation or heavy metals generation exists, covering may be indicated if the facility's containment liner system is questionable or if the post-closure water balance indicates that the facility lacks long term evaporative capacity. In addition, the ability to place cover materials on a tailings facility may be severely limited early in the closure sequence by the lack of shear strength and the consolidation settlement potential of the tails, until densification has had the opportunity to occur. Also, covering of the tails would inhibit densification by reducing the evaporation of the liquids expelled during the consolidation process.

4.5.3 Combined Detoxification and Closure/Cover Systems

The level of certainty resulting from both detoxification and covering of the heap leach facility would be expected to be only marginally greater than that expected from detoxification alone. This is due to the fact that after detoxification has been successfully completed, the cover will only serve to prevent precipitation from entering the detoxified ore. However after the ore has been detoxified, drainage of the facility should be implemented, provided there are no reasons why the facility cannot be drained and accept percolated precipitation waters. The exception would be those ores exhibiting the potential for acid or heavy metals generation. Even in these cases, if the containment capacity of the facility can be shown to be sufficient as a result of a post closure water balance analysis, and the containment liners are adequate, the need for cover still may be questionable.

The level of certainty to be expected as a result of covering tailings facilities after successful detoxification has been completed, would be only marginally greater than the level of certainty expected from the detoxification process alone. This results from the fact that the cover will prevent the percolation of precipitation rainfall into the detoxified ore and will inhibit further densification of the tails, over the long term. If the tails do not possess the potential for acid or heavy metals generation, drainage of the system should be considered. Otherwise, if it can be shown that the capacity of the facility is sufficient by conducting a post closure water balance analysis, and that the containment liners are adequate, the necessity for a cover system may be questionable.

4.6 Other Technologies to Achieve Commission Policy

TRC has evaluated several process technologies that appear to be suitable for cyanide removal and/or reuse, cyanide destruction and metal precipitation. Each of these methods has strengths and weaknesses and no one method is superior for every situation. TRC has concluded that a flexible approach to address site-specific characteristics provides the best means for achieving facility closure objectives, as stated by the Commission.

4.6.1 Detoxification Technologies

The technical evaluations (refer back to Section 3.0 for discussion) have centered upon demonstrated methods to oxidize and detoxify alkaline cyanide solutions. However, to efficiently achieve ultra low cyanide and metals concentrations in process effluents contents, other emerging techniques such as engineered biooxidation may warrant investigation.

4.6.2 Closure/Cover Technologies

The technical evaluations have centered on the prescribed cover system as described in the proposed rules. Within OAR 340-43-808(5), it is specified that construction of the cover shall generally follow the principles and practices contained in EPA/530-SW-89-047 "Technical Guidance Document - Final Covers on Hazardous Waste Landfills and Surface Impoundments". However, in view of the technological feasibility of detoxification of cyanide solutions, TRC concludes that appropriate closure and/or cover technologies may more closely relate to those methods/systems employed in containment of "non-hazardous" wastes.

Given that detoxification reduces the toxicity release potential associated with tailings or spent heap leach material, composite cover systems (as typically employed in hazardous waste management units) may represent no beneficial gain in containment of "contaminants". Where precipitation infiltration, dust generation, or aesthetic concerns are judged to be of critical importance at a given facility, sufficient mitigative containment can be gained through employing cover systems proven to be effective for such applications. These generally include options such as direct revegetation; soil or topsoil cover with revegetation; or stabilization. Each option can be modified, up to and including use of geomembrane materials, where site specific conditions warrant additional protective measures.

APPENDIX A-1

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LIST OF REFERENCES

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APPENDIX A-2

RECORD OF CONTACTS

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ MINING RULES

DATE: 5/4/92 TIME: 1230 PHONE: ( )

TO: JIM BECK OF: TRC

FROM: JACK CLARK OF: WESTEC - DENVER

SUBJECT: RE: CONTRACT AWARD & LEAK DETECTION SYSTEMS

DISCUSSION:

MR. CLARK CONTACTED TRC TO CONFIRM THAT TRC REC'D AWARD OF CONTRACT. HE OFFERED TECHNICAL INFORMATION IN SUPPORT OF LEAK DETECTION CAPABILITY FOR HEAP LEACH PAN.

INFORMED MR CLARK THAT LEAK DETECTION ASSESSMENT WOULD BE LIMITED TO LINER EVALUATIONS AND WOULD NOT NECESSARILY EXPAND INTO EVALUATION OF LEAK DETECTION SYSTEMS. REQUESTED THAT IF HE FELT HE HAD INFORMATION OF VALUE TO THE STUDY THAT HE FORWARD SAME DIRECTLY TO H. SAWYER WITH A SPECIFIC REQUEST THAT IT BE FORWARDED TO TRC. CONCLUDED CONVERSATION. [END]

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ MINING RULES

DATE: 5/4/92 TIME: 1300 PHONE: ( )

TO: JIM BECK OF: TRC

FROM: DIRK VAN ZYL OF: GOLDER ASSOC. - DENVER.

SUBJECT: RE: CONTRACT AWARD & LINER TECHNOLOGY

DISCUSSION:

MR. VAN ZYL CONTACTED TRC TO CONFIRM THAT TRC REC'D AWARD OF CONTRACT. HE OFFERED A NUMBER OF REFERENCES AND INDIVIDUALS AS POINTS OF CONTACT TO PROVIDE TECHNICAL INFORMATION ON LINER TECHNOLOGIES.

JMB REQUESTED THAT ANY INFORMATION IN THIS REGARD BE SUBMITTED DIRECTLY TO H. SAWYER (DEQ) FOR DEQ APPROVAL AND SUBSEQUENT PROVISION TO TRC. CONCLUDED CONVERSATION.

[END]

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ

DATE: 5-7-92 TIME: 3:00 PHONE: ( ) 623-8567

TO: N.S. LYNN OF: LYNTEK

FROM: GVJ OF: TRC

SUBJECT: Cyanide DESTRUCTION

DISCUSSION:

Reviewed general process conditions for CN destruction. Nick offered loan of literature collected on subject including general info and copies of regulations in various western states.

Note: personal visit conducted on 5-10-92 at Lyntek — discussed alkaline chlorination, AVR, peroxide applications, including pad rinsing.

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: Oregon DEQ

DATE: 5-7-92 TIME: 1100 PHONE: ( ) 303-643-5000

TO: BILL LAMPARD OF: CYRRUS -

FROM: GV JERGENSEN OF: TRC.

SUBJECT: AVR —

DISCUSSION:

REQUESTED INFO ON AVR technology as developed and patented by Cyprus. Mr. Lampard promised a contact from one of his people to find out what we (TRC) needed specifically,

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ

DATE: 5-7-92 TIME: 11:00 PHONE: ( ) 201-818-3715

TO: Roy Norcross OF: DEGUSSA

FROM: GVJ OF:

SUBJECT: H_2O_2 IN CYANIDE DESTRUCTION

DISCUSSION:

REQUEST FOR TECHNICAL LITERATURE ON CYANIDE DESTRUCTION USING H_2O_2.

REVIEWED APPLICATION REQUIREMENTS -

NOTE: LITERATURE RECEIVED

FOLLOW-UP CALL 6-10-92 TO ACQUIRE SPECIFIC INFO ON OK TEDI AND OTHERS -

BARRICK - GOLDSTRIKE - TREATING BARRENS* TO ACHIEVE 20 PPM WAD (and free) CN

NOTE! This probably means CIP tails -

WILL REQUEST SPECIFIC APPLICATION DETAILS - IF WARRANTED FOR LATER FOLLOW-UP.

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: 0050

DATE: 5-11-92 TIME: 8:30 PHONE: ( )

TO: GVJ OF: TRC

FROM: Ross Jenkins OF: Cyprus

SUBJECT:

DISCUSSION:

CYANISORB PROCESS -

Mr. Jenkins called, as referred by Mr. Lombard of Cyprus. Discussed AVR technology — Promised Literature and agreed to meet at our convenience to present technology.

Literature to be sent. (Received 5-22)

Note: follow up meeting(s) planned. 5-28.

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958-Q82 PROJECT: ODEQ MINING RULES

DATE: 5/13/92 TIME: 11:00 A.M. PHONE: (702) 687-4670

TO: BOB CARLSON OF: NEVADA NDEP

FROM: R.V. BECK OF: TRC

SUBJECT: HEAP LEACH PAD LINER SYSTEMS

DISCUSSION:

PADS: 1) 2-LINER SYSTEM

2) PRIMARY LINER MAX $K = 1 \times 10^{-7}$ CM/SEC CLAY OR FML. (CLAY LINER 1FT. THICK)

3) SECONDARY LINER MAX $K = 1 \times 10^{-6}$ CM/SEC IF L.D.S. NOT USED OR 1×10^{-5} CM/SEC IF L.D.S. IS USED. (1FT THICK)

4) GEOTEXTILE/GEONET ACCEPTABLE

5) FREE DRAINING MATERIAL REQUIRED ABOVE PRIMARY LINER TO RELIEVE HEAD

PONDS: 1) 2-LINER SYSTEM

2) PRIMARY LINER $K \leq 10^{-7}$ CM/SEC CLAY OR FML WITH $K \leq 10^{-12}$ CM/SEC. CLAY LINER 1FT THICK.

3) SECONDARY LINER 1' OF 1×10^{-7} CM/SEC CLAY OR FML W/ $K \leq 10^{-12}$ CM/SEC

4) LCRS GEONET OR PERMEABLE MATERIAL

TELEPHONE CALL LOG

PROJECT NO. ______ PROJECT: ______

DATE: ______ TIME: ______ PHONE: ( ) ______

TO: ______ OF: ______

FROM: ______ OF: ______

SUBJECT: ______

DISCUSSION:

DETOX OF H.L. FACILITIES:

1) SPENT ORE TO BE STABILIZED TO CN^- LEVELS BELOW 0.2 ppm WAD AT pH BETWEEN 6 AND 9.
2) LEACHATE TO BE CHARACTERIZED FOR METALS AND SULPHIDES.
3) UPON APPROVAL RECLAMATION MAY COMMENCE.

DETOX OF TAILING PONDS:

1) SHOULD BE STABILIZED IN PLACE W/ REGARD TO SULPHIDES AND ACIDS
2) LINER OF 10^{-6} CM/SEC IS REQUIRED FOR BOTTOM OF POND
3) OPERATIONS STRESS THE EMPHASIS OF A FLUID MANAGEMENT PLAN

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958-Q82 PROJECT: ODEQ MINING RULES

DATE: 5/13/92 TIME: 2:00 P.M. PHONE: (208) 334-5898

TO: JERRY YODER OF: DEQ - IDAHO

FROM: R.V. BECK OF: TRC

SUBJECT: HEAP LEACH PAD LINER SYSTEMS

DISCUSSION:

PADS: 1) SINGLE LINERS ACCEPTABLE FOR H.L. PADS.

2) FML OR CLAY ACCEPTABLE PROVIDED $K \leq 10^{-6}$ CM/SEC.

3.) L.D.S. NOT REQUIRED PER SE BUT MAY BE NECESSARY AS PART OF W.Q. MONITORING PROGRAM

PONDS: 1) DOUBLE LINER SYSTEM

2) L.D.S. NECESSARY

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ

DATE: 5-19-92 TIME: 4:00 PHONE: ( )

TO: Andre Douchane OF: Battle Mountain

FROM: GVJ OF: TRC.

SUBJECT: CN Desti

DISCUSSION:

Inquired about BMGC Alk Chlor. at Fortitude Mine. Referred to Art Lefler — consult.

Alk Cl_2 utilized at Fortitude to reduce Free/WAD CN to less than 50 ppm.

BMGC plans to implement SO_2 process (INCO) at San Luis if site tests support process. Plan to reduce free/WAD CN "significantly" below 30 ppm. In interim will use a waste from steel processing, $(ZnFe(SO_4)_2)$? Zinc ferrous sulfate to reduce CN and heavy metals to comply with permit standards.

Note — Consider zinc ferrous sulfate to be an emergency measure. INCO process selected as candidate due to longer term reliability and efficiency.

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ MINING RULES

DATE: 5/21/92 TIME: PHONE: (202) 737-1872

TO: MS. ANN NAFFIER OF: MINERAL POLICY CENTER WASH. D.C.

FROM: JIM BECK OF: TRC

SUBJECT: REQUEST FOR TECHNICAL INFORMATION

DISCUSSION:

CONTACTED MINERAL POLICY CENTER TO REQUEST TECHNICAL DOCUMENTATION RELATING TO HEAP LEACH LINER, CYANIDATION, AND CLOSURE/RECLAMATION ISSUES.

MS. NAFFIER INDICATED THAT SHE WOULD SEND ALL BACK ISSUES OF CLEMENTINE PUBLICATION; THAT THEY HAD SIGNIFICANT AMOUNT OF MATERIAL & MR. HOCKING WILL PREPARE SOME MATERIAL; AND REFERRED ME TO MR. WILL PATRICK IN BOZEMAN MT. OFFICE.

[END]

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ MINING RULES

DATE: 5/21/92 TIME: PHONE: (406) 585-9009

TO: MR. WILL PATRICK OF: MINERAL POLICY CENTER BOZEMAN MT.

FROM: JIM BECK OF: TRC

SUBJECT: REQUEST FOR TECANICAL INFORMATION

DISCUSSION:

CONTACTED W. PATRICK TO FOLLOW-UP ON D.C. OFFICE REFERRAL. EXPLAINED REASON FOR CALL, TRC CONTRACT, AND BASIS FOR REQUEST FOR TECHNICAL INFORMATION RE: LINER SYSTEMS, CYANIDATION, ETC. EXPLAINED THAT RECORD OF PROCEEDINGS CONTAINED PRIMARILY NEWS CLIPPINGS AND THAT TRC WAS LOOKING FOR INFO OF A DOCUMENTABLE TECHNICAL NATURE TO EVALUATE. REQUESTED THAT HE COMPILE SAME AND DELIVER TO H. SAWYER FOR FORWARDING TO TRC. HE INDICATED THAT HE WOULD DO SO.

[END]

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ MINING RULES

DATE: 5/28/92 TIME: PHONE: ( )

TO: JIM BECK OF: TRC

FROM: WILL PATRICK OF: MINERAL POLICY CENTER

SUBJECT: TECHNICAL INFORMATION REQUEST.

DISCUSSION:

W. PATRICK CALLED TO GET CLARIFICATION AS TO MY REQUEST FOR INFO. FURTHER EXPLAINED. HE SAID HE'D BE GETTING APPROPRIATE MATERIALS TOGETHER FOR CONSIDERATION AND WOULD FORWARD TO. H. SAWYER. END

TRC

~~TELEPHONE CALL~~ LOG
PROJECT
OUTSIDE MEETINGS -

1/2

PROJECT NO. 11958 PROJECT: ODEQ

DATE: 5-28-92 TIME: ______ PHONE: ( ) ______

TO: ______ OF: CYPRUS GOLD -

FROM: ______ OF: ______

SUBJECT: ______

DISCUSSION: Meeting to REVIEW CYANISORB® TECHNOLOGY (Patented)

Mr. J. Sturgess - Director Env. Affairs Cyprus Copper Co.
Mr. A. Goldstone - Process Engineer Cyprus Gold
Mr. R. Jenkins - Bus. Dev. Engineer / Cyprus Gold.
M. J. Beck - Project Mgr. TRC.
Mr. G. Jergensen, Process Mgr. TRC

Reviewed Development of Cyprus' AVR Process called CYANISORB. Mr. Goldstone supervised testing and process development at The Golden Cross Mine. Site located in rainy climate, in a major trout fishery habitat. Process said to produce less than 30ppm free and WAD levels and project is permitted without a FML liner.

Cyprus believes that technology is now available to remove CN from slurries at high efficiency. TRC referred to papers by Goldstone and Mudder and Omofoma/Hampton.

TRC

Job: ODEQ Date:

Subject | Item Discussed | Action By | Date

Cyprus offered copies of New Zealand permit, if thought useful, to present exercise.

Other information, including process patent provided by mail.

Specific Process Information generally confidential.

Cyprus, in selling (offering) their technology truly believe that, in the CYANISORB Process, they have solved the problems that limited the use of AVR on slurries.

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ MINING RULES

DATE: 6/3/92 TIME: PHONE: ( )

TO: JIM BECK OF: TRC

FROM: DIRK VAN ZYL OF: GOLDER ASSOC. - DENVER

SUBJECT: PROJECT SCHEDULE

DISCUSSION:

MR. VAN ZYL CALLED TO INQUIRE ABOUT PROJECT COMPLETION SCHEDULE, SPECIFICALLY DRAFT REPORT SUBMITTAL.

TOLD HIM CONTRACT SPECIFIED DELIVERY DATE WAS 6/19. REFERRED HIM TO ODEQ IF ADDITIONAL QUESTIONS. CONVERSATION CONCLUDED. END

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 PROJECT: ODEQ

DATE: 6-9-92 TIME: 11:00 PHONE: ( ) 721-9111

TO: M. Both OF: Minproc

FROM: GVJ OF: TRC

SUBJECT:

DISCUSSION: Application history of CN destruction processes.

Mr. Both provided comment on various processes, from Minproc experience and his own personal experience.

1. Battle Mountain Gold "so called" CN Removal System at San Luis IS NOT a true AVR system — Tailings acidified prior to release to lined pond — however CN not recovered and no extra effort provided to "strip" CN from acidified tails.

2 Alk Chlorination Works Effectively to reduce CN but requires high amounts of reagents, etc. process is finding decreasing usage.

TRC

TELEPHONE CALL LOG

2/2

PROJECT NO. ______ PROJECT: ______

DATE: ______ TIME: ______ PHONE: ( ) ______

TO: Murray OF: ______

FROM: ______ OF: ______

SUBJECT: ______

DISCUSSION:

3. INCO is said to have some 70 installations. Murray promised FAX on list of Applications ——

4. Minproc bidding on SO_2 system (Construction)/Design-Construction of SO_2 processes in several projects -

5. H_2O_2 systems not as widely used but, when properly applied (in the right situations) are effective.

TRC

TELEPHONE CALL LOG

PROJECT NO. 11958 Q82 PROJECT: ODEQ MINING RULES

DATE: 7/15/92 TIME: 1600 PHONE: (907) 789-9114

TO: MR RICK RICHINS OF: COUER d'ALENE MINES

FROM: JIM BECK OF: TRC

SUBJECT: RE: THUNDER MOUNTAIN MINE ENVIRONMENTAL LEADERSHIP AWARD.

DISCUSSION:

CONTACTED MR. RICHINS IN RESPONSE TO READING ARTICLE IN MINERAL POLICY CENTER PUBLICATION "CLEMENTINE"; INQUIRED ABOUT DESIGN PARAMETERS FOR LINER SYSTEM, CYANIDE DETOXIFICATION, AND COVER/CLOSURE.

LINER – NAT CLAY + AGGREG LEAK DET. SYSTEM.
+ 80 MIL HDPE + 6" SEALED ASPHALT
+ 18" LEACHATE COLLECTION ZONE.

DETOX – ALKALINE CHLORINATION WASH/RINSE TO
0.2 mg/L 2-hr/24 hr STABILIZED.
PLACED IN PIT OR TO COMP. CLAY AREA.

COVER – 6" COMP CLAY + TOPSOIL/VEG.

NOTE - ALL CLAY NATURALLY OCCURRING ONSITE

END

APPENDIX A-3

LIST OF PREPARERS

The following alphabetical list of TRC contributors prepared the Report of Findings on Specific Technical Issues - State of Oregon Proposed Chemical Mining Rules:

1. *Beck, James M.*

   Mr. Beck is a Registered Professional Engineer with fifteen years experience in mining and environmental engineering. He holds a B.S. degree in Mining Engineering from the Michigan Technological University (1977) and has completed studies toward an M.B.A. degree at the University of Colorado. He has extensive experience in the design and evaluation of heap leach facilities; cyanide destruction; liner, cap and cover systems; and in heap leach and tailing facility closure and site reclamation. This experience has been gained through approximately five years previous employment with Anaconda Copper Company in addition to employment as a mining and environmental consultant for the past ten years. His recent experience has included technical critique and comment on a number of proposed mine waste regulatory programs.

2. *Beck, Richard V.*

   Mr. Beck is a Registered Professional Engineer with over fifteen years experience in all aspects of solid waste management facility geotechnical design and construction. He holds a B.S. degree in Physics from Elmhurst College (1975), a B.S. degree in Civil Engineering from Tri-State University (1977), and an M.S. in Civil Engineering (Geotechnical) from the University of Colorado (1983). As a geotechnical engineer, he has extensive experience in the design and construction of mining and solid waste facilities, including all aspects of liner and leachate collection systems, tailing impoundment facilities, and cap and cover systems for facility closure.

3. *Jergensen, Gerald V.*

   Mr. Jergensen holds a B.S. degree in Minerals Engineering from the Colorado School of Mines (1965), and an M.B.A. degree from the University of Colorado (1972). He serves as an adjunct professor of Metallurgy at the Colorado School of Mines. As a mineral processing engineer, Mr. Jergensen has extensive experience in process chemistry and design and evaluation of heap leaching and tailing treatment operations.

4. *Muhm, James R.*

Mr. Muhm is a Certified Professional Geologist with over forty years experience in regulatory affairs and community relations. He holds a B.S. degree in Geology from the University of Wyoming (1950). He was recently a major participant in a cooperative rulemaking effort under contract to the state of Minnesota, culminating in the 1990 publication of "The Report on the Mining Simulation Project (Non-Ferrous Mineral Project)". He was subsequently engaged in a similar regulatory development program under contract to the state of Maine, for development of a statewide non-ferrous metallic mining regulatory program.

APPENDIX B-1

ODEQ COMMENTS/RESPONSES

APPENDIX B-1: ODEQ COMMENTS/RESPONSES

TRC has assembled ODEQ comments (as contained within the July 2, 1992 letter) and provided the following responses, assembled by Section corresponding with the report format:

1) Section 1: INTRODUCTION

1-1 *ODEQ. Your draft report deviated from the specific technical questions in the scope of work and inappropriately presented suggestions on policy issues that have been extensively considered and debated by the Commission. As noted in our attached comments, all such policy suggestions must be eliminated from the final report. You are welcome to submit your views on policy issues to the Commission if you choose by letter or separate document. If you do so, we and the Commission will consider them as we would any other commentator – but we will not consider them a part of the work we contracted for nor a formal part of the report. This report, to be consistent with the scope of work in the contract, must present technical information and analysis in response to the questions posed, and be free of recommendations or opinions you may hold which were not a part of the contract or scope of work.*

TRC RESPONSE: TRC does not agree that the draft report deviated from the specific technical questions in the scope of work, particularly since the Request for Proposal was entitled "Technical Advice on Mining Rules". TRC examined the technical aspects of the issues and drew conclusions therefrom. Nevertheless, TRC has modified appropriate sections of the report accordingly, as discussed below, to satisfy ODEQ concerns.

1-2 *ODEQ. This section (1) presents significant concerns. The conclusions section (1.3) should be deleted from this report in its entirety. If TRC wishes to make policy suggestions to the Commission, it may do so by letter addressed to the Commission. The scope of work in this contract specifically asks for technical response to specific questions and specifies that the consultant is not to cross the line into policy.*

TRC RESPONSE: TRC has deleted Section 1.3 to satisfy the ODEQ directive.

While TRC agrees that the scope specifically asks for technical response to specific questions, we note that each issue response format, as prepared by ODEQ, contained a specific question pertaining to identifying alternative technologies or systems that equally or more effectively achieve the stated Commission policy. TRC presented those alternatives, with caveats pertaining to their suitability or limitations in specific applications. Likewise, TRC identified caveats pertaining to the suitability or limitations in ODEQ proposed criteria that could inhibit the ability to achieve stated Commission policy. This suggests that either (1) one or more of the identified alternatives, or (2) the proposed rule criteria may have difficulty achieving the stated Commission policy objectives at all times and in all circumstances. Implicit in such a conclusion is that site-specific, or a situational-specific application may be the only way to achieve stated Commission policy at all times. If that is perceived to be a policy suggestion, it is an erroneous perception. TRC feels rather strongly that such statements contained within the body of the draft report are technical conclusions based on professional judgement, as opposed to being unsolicited policy statements.

1-3 *__ODEQ.__ The conclusion at the top of Page 7 regarding avian mortality should be deleted. It is not appropriate for the scope of work for this contract.*

TRC RESPONSE: TRC has removed Section 1.3 from the final report. This is due to the fact that there is insufficient evidence to support toxicity risk potential comparisons between 50 ppm and 30 ppm. However, we disagree that its inclusion is "not appropriate", and respond that inclusion of the avian mortality concept was introduced with extreme emphasis in the rulemaking proceedings by parties to the rulemaking. TRC was requested to review the record of the rulemaking proceedings maintained in Portland to assure that all concerned parties comments received due consideration. As a matter of record, it can be noted that an estimated ninety percent of all written documentation in those files classified as submittal from The Wilderness Society, Concerned Citizens for Responsible Mining, and related constituencies pertained to copies of newspaper articles and various state regulatory enforcement documentation citing avian mortality concerns. Of particular note, comments to the draft report from Concerned Citizens for Responsible Mining were submitted containing attachments dedicated to the sole issue of avian mortality. We note that Question 2 d.(2) on Page 5 of the RFP pertains to "toxicity"; to evaluate any material reduction would require addressing the definition of toxicity.

1-4 *__ODEQ.__ DEQ would recommend that TRC consider deleting the Record of Findings (Section 1.2) and rename Section 1.0 from Executive Summary to Introduction. There is substantial information within the body of the report, and it is virtually impossible to adequately capture it in a few bullets in an executive summary. Further, an attempt to summarize has the risk of crossing the line into policy matters.*

TRC RESPONSE: TRC disagrees that summarizing technical findings intrudes into policy formulation. The summary was prepared to assist reader comprehension of an involved technical analysis. TRC reaffirms the suitability of its summary in the revised Section 1.2.

2) Section 2.0: Questions/Comments on Liner System Design

2-1 *__ODEQ__ - The organization of this section requires the reader to read through a great deal of repetitive material. This makes it easy to get lost and difficult to understand the comparative differences and similarities between liner systems. It would seem easier to assimilate the material if the discussion were reorganized to take one question or evaluation criteria at a time and consider each of the three liners evaluated in a comparative sense. e.g., consider the performance characteristics of the leak detection systems of the three liners in the same section. Then summarize the total evaluation of each liner system at the end.*

TRC RESPONSE: TRC agrees that a great deal of information is presented, and that it can appear repetitive. TRC considered a number of presentation formats, including that suggested by ODEQ (i.e. consider the performance characteristics of the leak detection systems of the three liners in the same section). However, it was determined that in using such an approach a greater degree of repetition and confusion resulted.

2-2 *ODEQ - Figure 2-1 c) presents a graphic picture of the alternative candidate liner system. This figure identifies two flexible membrane liners (FML). The narrative description of the liner system in the text only identifies one FML. This needs to be clarified.*

TRC RESPONSE: The "alternative liner system candidate" as presented in Figure 2-1 (c) should have only one flexible membrane liner as per the text description. Figure 2-1 (c) has subsequently been corrected to agree with the text.

2-3 *ODEQ - Page 15 and subsequent pages in this section – The leak detection criteria is from the DEQ rule proposal – not the EQC policy statement. The Commission policy does not specify permeability requirements, the DEQ proposed rules do.*

TRC RESPONSE: It should be noted that as per the RFP, both the ODEQ and OMC proposed liners specified that they would be able to meet the 400 gpd/acre leak detection criteria and within the 10 week time period. As a result, this information was utilized by TRC for the analysis, in addition to review of the systems with regard to the EQC policy. As appropriate, TRC has modified text in the final report to properly differentiate between EQC policy and ODEQ proposed rules.

2-4 *ODEQ - Somewhere in the report, it would be helpful to clearly display in a comparative sense the differences between permeability levels of 10^{-7}, 10^{-11}, 10^{-6}, and 10^{-2} with respect to thickness of material and distance that fluid will move in a given period of time. Since the Commission policy statement only specifies that any leak will be detected and that correction and cleanup can occur before there is a release to the environment from the boundary of the last liner, a better understanding of how fast material will move and how far will give the Commission information needed to make the ultimate policy judgement on the specific leak detection and permeability criteria necessary in the rules.*

TRC RESPONSE: TRC has prepared an illustration (Table 2-6) which depicts the relationships between (1) the permeability of the liner components, and (2) the depths of leachate head buildup in the leak detection layer, and, (3) the thickness of the bottom liner. It is important to realize that permeability alone does not entirely influence the magnitude or rate of leachate leakage through a liner or liner defect, but that these other parameters contribute similarly. In essence, the issue should be the allowable resultant leakage rate through a liner or liner defect which is a function of all three parameters listed above.

2-5 *ODEQ - Definitions were provided on page 34 for various terms used for "geo" materials. It would be helpful to put the definitions in terms that a lay person would better understand and visualize. Examples of typical dimensions or use situations may be helpful.*

TRC RESPONSE: Definitions of "geo" materials as previously presented on page 34 of the report, have been moved to the beginning of Section 2.0 and placed in a "glossary" format. Some typical applications of the materials have also been included following the definitions, however TRC is uncertain as to how the definitions can be further reduced to lay terms.

2-6 *<u>ODEQ</u> - Page 25. Some additional clarification or discussion of methods for placement of materials on the top FML so as to prevent puncture would be helpful. References were made on previous pages to "sequenced ore loading" and a properly designed solution recovery system (leachate collection system) placed between the top liner and the ore. Discussion to tie the significance and importance of these items together would be helpful.*

TRC RESPONSE: Methods for placement of ore and sequenced loading schemes need to be addressed by the heap pad designer on a site specific basis depending on the site, angularity of the ore, cushioning methods used, liner type and thickness as well as equipment used to place the ore on the pad. Numerous discussions are made throughout the report referencing the leachate collection system's benefit in aiding the reduction in hydraulic head over the primary liner and enhancement of the heap stability.

2-7 *<u>ODEQ</u> - Page 29. In the third paragraph, the second sentence reads: "The leak detection system's permeable material component effectively serves as a liner system component..." This seems to need some clarification.*

TRC RESPONSE: This sentence has been revised. The leak detection system should effectively serve as a component of any liner system.

2-8 *<u>ODEQ</u> - Page 31. The report notes the importance of preventing drying of the clay liner until the secondary liner or other appropriate materials can be placed over it to retard loss of moisture. The purpose is to prevent desiccation cracking which adversely affects the overall permeability of the liner. Assuming moisture is maintained until the secondary liner is in place, what is the likelihood of drying and desiccation cracking occurring over an extended period of time? Is there any information available on this issue?*

TRC RESPONSE: The purpose of this discussion was to convey to the reader that methods should be observed to prevent, inasmuch as is possible, the occurrence of desiccation cracking in the clay liner. Desiccation cracking is very difficult to entirely prevent for liners constructed of earthen materials which are compacted to high densities in order to achieve low permeabilities. In general the higher the moisture content of the liner the more pliable it will be and will be less prone to desiccation cracking. However, as the liner becomes more moist and pliable (at water contents beyond the water content at optimum density) its density decreases while the permeability generally increases and the shear strength decreases. At higher water contents the workability of the clay becomes increasingly more difficult, as well. Therefore, the complete elimination of desiccation cracking may not be practical or reasonable to expect for earthen liners. Even the utilization of FML materials or other such low permeability materials over such clay liners will only retard the loss of moisture from the liner and will not completely eliminate it, since moisture loss from the liner in the form of water vapor will still pass through the FML. The extent of loss of moisture from a clay liner will depend on the climate, initial moisture content of the liner, overlying materials and the strength of the soil particle-water bonds in the clay, which is function of the soil mineral composition and chemistry. These are all site-specific factors. To determine the likelihood of drying and cracking occurring over time, one would have to examine the site-specific design and operational parameters. Many references are cited throughout this section to provide the reader with sources of additional information.

2-9 *<u>ODEQ</u> - Page 42. Reference is made in the 5th line down to ...the overlying secondary and underlying bottom liners... It seems in this situation that the "overlying secondary" is really the top or primary liner. The identification of liner components using the terms primary, secondary, top, bottom, is at times not consistent.*

TRC RESPONSE: This sentence has been revised to be more generic since the purpose of the cushioning materials would be to protect the geosynthetic liners in contact with materials which have the potential to puncture them. The terms "primary" and "top" liners are synonymous. "Secondary" liners are considered the next liner below the primary or top liner and in the case of a two-liner system, the term secondary liner would also be synonymous with the term "bottom" liner.

2-10 *<u>ODEQ</u> - Pages 47-49. It would be helpful to be more explicit as to how the liner systems are consistent with the EQC policy.*

TRC RESPONSE: Evaluations of the liner systems with regard to meeting the EQC policy were based on the analyses of each liner system as presented in Section 2.1. as well as what TRC believes to be good engineering judgement, since the EQC policy has no specific criteria or performance standards to compare each liner to. Therefore TRC used its best engineering judgement and the results of the investigations to determine whether or not a liner system has the potential to satisfy the EQC's very general policy requirements.

2-11 *<u>ODEQ</u> - Page 65 and Table 2-5. The information provided in the table regarding other state requirements for liners presents an obvious question regarding the real difference between permeabilities for liners of 10^{-3}, 10^{-4}, and 10^{-7}. Addressing the earlier comment (2-3) regarding this issue would help to put some perspective on the differences.*

TRC RESPONSE: Please see the response to comment number 2-3.

2-12 *<u>ODEQ</u> -Figure 2-8. This figure presents alternative liner configurations that are <u>potentially</u> capable of meeting the EQC policy requirements. The configurations are general, and specifications are minimal. One would assume that there are real differences between these liner configurations with regard to the risk of release, the degree of certainty that they would satisfy the Commission policy, etc. The prior analysis of liner components provides some basis for the reader to make subjective judgements of the relative performance characteristics of these liner configurations. There is insufficient information, however, to leave the reader comfortable that each liner would indeed meet the Commission policy within some limits of certainty. Some further explanation seems appropriate.*

TRC RESPONSE: The alternative liner configurations as presented in Figure 2-8 of the DRAFT report were included in the document as other potential liner candidates worthy of further consideration in meeting the EQC policy requirements if the DEQ so desires. TRC never intended to analyze more than one alternative liner system candidate under its contract with DEQ and believes that it has presented one alternative liner system and variants thereof, capable of meeting the EQC policy. TRC included this figure for the reader's information and to illustrate that many other types of liner systems are commonly utilized, and may warrant further consideration or investigation by the DEQ.

3) Section 3.0: Questions/Comments on Tailings Treatment:

3-1 *ODEQ - Pages 80-81. All references to avian mortality and WAD cyanide levels should be eliminated from this report. This crosses into policy discussion which is specifically outside the scope of work specified in the contract. Discussion should focus on technology for removal and reuse of cyanide, and the cyanide levels that can be achieved with such technology.*

TRC RESPONSE: The Commission asked: "Do the requirements for removal and reuse of cyanide materially reduce toxicity and potential for long-term cyanide and toxic metals release from mill tailings? Avian mortality represents an important, highly visible aspect of the toxicity question.

A limited review of available toxicity information suggests that the level of free and WAD cyanide at which bird mortalities begin to occur is about 50 ppm. The ODEQ standard of 30 ppm provides a reasonable and achievable level of safety relative to the information presently available. Additional research on the appropriate level of allowable cyanide will either support the standard or it won't. If new information suggests an even lower level, then the Commission is on very solid ground in reducing the standard as appropriate.

TRC has concluded that the 30 ppm standard can be achieved with presently available technologies, including recovery and reuse, in most foreseeable situations.

TRC has concluded that the standard is technically achievable by most chemical destruction techniques, and incorporated this finding into the text.

3-2 *ODEQ - DEQ would not agree with the conclusion that "Reuse of cyanide in and of itself would not reduce the immediate or long term toxicity potential..." Reuse would be consistent with the intent of Oregon's Toxic Use Reduction Law. Reuse would reduce the quantity of chemicals transported onto the site during the life of operations, and would therefore reduce the potential for accidental release during transport, storage, handling, etc. If cyanide is removed, but not reused, it would have to go somewhere. The options would appear to be to transport it off site to another location for use or destruction and disposal, or to chemically convert it to a less toxic form for disposal on site. Either option would not be consistent with the Commission policy to reduce the potential for release to the greatest degree practicable.*

TRC RESPONSE: If the standard of 30 ppm for free and WAD cyanide can be achieved by (1) recovery and reuse, or (2) by alternative technologies, then there is no substantial difference in the immediate or long term potential for release at that site.

Recovery and reuse (within the process) does NOT reduce the amount of cyanide within the process system. Neither does recovery and reuse reduce the amount of free or WAD cyanide that is impounded, and which constitutes the principal toxicity threat to the environment. Recovery and reuse does reduce the quantity of cyanide consumed over the life of the process. (As noted in the TRC draft report).

3-3 *ODEQ - Page 88. At the end of the page, the statement is made that "Heavy metals are also effectively removed." The term removed is not used consistently in the report. It would seem that removed would apply to "physically separated" and should not be used to refer to alteration of chemical form to a less soluble and less mobile form. If there is actual physical removal of heavy metals, where do they go? How are they to be handled and disposed of?*

TRC RESPONSE: Heavy metals will be precipitated from solution rather than removed from the system. Generally, once the free and WAD cyanides are reduced (by removal or destruction) below the concentrations of the metals in solution, these metals will precipitate as hydroxides, carbonates and other metal complexes. Although the metals remain in the solid portion of the tailings or heaps, they have been converted to compounds of much lower solubility and mobility, and do not constitute a realistic threat to the environment.

The term "removed" has been accordingly changed to "precipitated from solution" or simply "precipitated", as appropriate.

3-4 *ODEQ - Page 92 and Section 4. Natural degradation should be taken advantage of during the life of the mine, before closure of the heap and tailings pond. Natural degradation is not very controllable or manageable. TRC correctly points out that it should not be considered an effective stand-alone technology.*

TRC RESPONSE: Natural degradation is not readily controlled in the short term. TRC also notes, however, that preliminary indications from the literature review made for this study suggests that the end result of the natural degradation process may be very predictable (i.e., very low final levels of both WAD and total cyanide concentrations).

4) Questions/Comments on Closure

4-1 *ODEQ - Pages 99-101 and Section 4.3.*

- *4.3.1 - TRC states that a heap can be effectively detoxified.*
- *4.3.2 - TRC states that covering would generally be beneficial, reducing water infiltration into the heap, thus inhibiting mobilization of metals, reducing potential for acid formation, and enhancing stability of the heap. TRC notes that a disadvantage of cover would be to reduce the potential for further natural degradation of residual cyanide left in the heap.*
- *4.3.3. - TRC states that detoxification will virtually eliminate free and WAD cyanide and will stabilize metal release, and that covering will provide no additional benefit and may in fact be deleterious to the detoxification attributes (provided that the ore does not contain metals or acid generating constituents such as sulfides, in which cases cover may be desirable). TRC further states that cover would generally not be*

warranted since provisions for drainage of waters from the heap could be implemented to insure that water buildup and stability problems do not occur.

The conclusions in these sections appear inconsistent. If the heap can be effectively detoxified, then the identified disadvantages associated with cover (reduced further natural degradation) would be largely negated, and the positive aspects of cover (reduced infiltration, inhibited mobilization of metals, enhanced stability of the heap) would be realized.

TRC RESPONSE: TRC only indicates that a heap can be effectively detoxified to 0.5 ppm WAD based on general mining industry experience. The results of this study indicate that cyanide degradation and attenuation in a heap can be achieved by individual or combined application of rinsing, chemical treatment, and natural degradation reactions. We have noted that 0.5 ppm free and WAD levels have been attained in heap closures in the short term. However, the amount of additional treatment and rinsing that will be required to attain the federal standard is unclear. With natural degradation and/or continued rinsing, lower concentrations may be achieved.

The detoxification, rinsing and closing process may require an extended period of active management. Until the specified standard is reached, TRC suggests that covering would reduce the potential for natural degradation to result in these lower levels of residual cyanide. TRC indicates that a cover may preclude attainment of the ultimate 0.2 ppm WAD closure requirement.

Rinsing and detoxification processes have been shown to lower the pH of both the detoxification solutions and of the heap itself. If there is a potential for acid generation, heavy metal mobilization could be inadvertently initiated during the detoxification process. In this instance, covering as soon as practicable may be warranted, even though the proposed 0.2 ppm WAD cyanide levels have not been attained within the heap.

In order to assure that the heaps remain stable it may be necessary to prevent the accumulation of water within the heaps. This can be achieved either by providing adequate provisions for evaporation and transpiration from the heaps or by isolating the heaps from infiltration of water. This may be a concern if the fluid buildup potential exceeds that of evaporation. Covering or other alternative technologies may be warranted where such is the case.

For clarification purposes, the following table has been prepared.

	Heap Leach Facility Closure			Tailings Facility Closure		
	Detox	Cover	Combined	Detox	Cover	Combined
Toxic Chemical Reduction	YES	NO	MAYBE	YES	NO	NO
Toxic Metal Reduction	NO	NO	MAYBE	MAYBE	MAYBE	MAYBE

4-2 *ODEQ - The suggested implementation of drainage of the heap to protect against water buildup (as opposed to cover) implies a potential need for treatment of drainage water, (particularly if detoxification is not uniformly effective throughout the heap) and continued monitoring of drainage water quality after closure. This approach seems inconsistent with the general intent of closure in a manner to reduce the need for ongoing maintenance to zero as soon as practicable, and prevention of the release of potentially toxic chemicals to the environment.*

TRC RESPONSE: The provisions for drainage would be of great value during the closure period so that maximum value is derived from the natural degradation processes. Also, the drainage points provide a ready monitoring point for the operator to observe the results and progress of the closure process and to modify the efforts as necessary to assure the quality of the end result. Monitoring of heap (or tailing) drainage appears to be unavoidable, although monitoring curtailment may be more appropriately linked to stabilized achievement of standards rather than an arbitrary time period such as 30 years, which is more appropriately applied to "hazardous waste" management units.

4-3 *ODEQ - Pages 101-102 Section 4.4*

- *In 4.4.3, TRC states that once detoxified, a cover designed to exclude air and water may provide little, if any quantifiable benefit with respect to toxicity release. The section goes on to note qualifications that the tails do not possess the potential for acid generation, heavy metals species have been removed from the system, and drainage is implemented as necessary to prevent fluid buildup.*

- *We would note that removal of heavy metals species from the tailings is not required by the current rule draft. It would seem that a closed, uncovered tailings facility would present a long term potential for production of leachate drainage that would require maintenance and monitoring, could require treatment, and would likely be inconsistent with the Commission policy regarding release to the environment of toxic chemicals.*

TRC RESPONSE: If the potential for acid production due to sulfides is significant, then a more complex covering system may be warranted. Only site specific tailings chemistry can provide an indication of the extent of such covering that will be necessary.

4-4 *ODEQ - Page 104. The conclusions of section 4.5.3 again appear to be based on an assumption that drainage is provided to prevent fluid buildup in the tailings. We have the same comments and concerns as expressed above on this issue.*

TRC RESPONSE: TRC is not presenting contradictions, but is identifying potential shortcomings. TRC is stressing the necessity for flexibility to select and implement appropriate engineering alternatives to achieve maximal results. Either provisions for (1) adequate water removal through transpiration and evaporation, or (2) prevention of water infiltration may be necessary to maintain the stability of a particular tailings impoundment.

Materials within tailings impoundments tend to consolidate and may ultimately reach a density that excludes further infiltration of water. At this point, the potential for acid generation diminishes. However, if acid generation potential is high at the outset, then methods for the exclusion of air (and thereby oxidation potential) may be required. This could require a cover or other alternative measures to assure compliance.

APPENDIX B-2

ODEQ COMMENT LETTER (AS RECEIVED)

Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

July 2, 1992

JUL 06 92

James M. Beck, P.E.
Manager Hazardous Waste Investigation and Engineering
TRC Environmental Consultants, Inc.
7002 South Revere Parkway, Suite 60
Englewood, CO 80112

Re: Draft Report on Findings on Specific Technical Issues - Proposed Chemical Mining Rules

Dear Mr. Beck:

The Department of Environmental Quality has reviewed the Draft Report and transmits its specific comments in the attachment to this letter. Pursuant to the Contract between TRC and the Department, the final report is due 15 days after receipt of these comments.

Under separate cover, we have already transmitted to you copies of the comments received from others who have reviewed the Draft Report. We urge you to read these comments from others, and to consider and respond to the comments regarding specific sections of your report as you deem appropriate in the preparation of your final report. We are aware that some of the comments deal with matters that are outside the scope of work in this contract and you should not attempt to consider or respond to such comments.

Your draft report deviated from the specific technical questions in the scope of work and inappropriately presented suggestions on policy issues that have been extensively considered and debated by the Commission. As noted in our attached comments, all such policy suggestions must be eliminated from the final report. You are welcome to submit your views on policy issues to the Commission if you choose by letter or separate document. If you do so, we and the Commission will consider them as we would any other commenter — but we will not consider them a part of the work we contracted for nor a formal part of the report. This report, to be consistent with the scope of work in the contract, must present technical information and analysis in response to the questions posed, and be free of recommendations or opinions you may hold which were not a part of the contract or scope of work.

Sincerely,

Fred Hansen
Director

FH:l
Attachment

811 SW Sixth Avenue
Portland, OR 97204-1390
(503) 229-5696

DEQ Comments on TRC Draft Report

These comments will start with Section 2 and end with comments on Section 1.

Section 2

General Comments.

The organization of this section requires the reader to read through a great deal of repetitive material. This makes it easy to get lost and difficult to understand the comparative differences and similarities between liner systems. It would seem easier to assimilate the material if the discussion were reorganized to take one question or evaluation criteria at a time and consider each of the three liners evaluated in a comparative sense. e.g., consider the performance characteristics of the leak detection systems of the three liners in the same section. Then summarize the total evaluation of each liner system at the end.

There is some confusion throughout the section on liners regarding the distinction between the Statement of Commission Policy as presented in the RFP, and the specific performance criteria that are contained in the rule language for the DEQ proposed Triple liner. In some instances, the other liners are evaluated in relation to the specifications in the DEQ proposed rule. Such comparison is helpful in understanding the differences between liners, however, the evaluation also needs to be clearly related to the elements of the EQC policy statement.

References in the text to figure numbers and the actual figures do not match up in all cases (beginning on page 59 with the reference to figure 2-5 which is actually figure 2.6).

Specific Comments

Figure 2-1 c) presents a graphic picture of the alternative candidate liner system. This figure identifies two flexible membrane liners (FML). The narrative description of the liner system in the text only identifies one FML. This needs to be clarified.

Page 15 and subsequent pages in this section -- The leak detection criteria is from the DEQ rule proposal -- not the EQC policy statement. (See general comment above.)

The Commission policy does not specify permeability requirements. The DEQ proposed rules do. (See general comment above.)

Somewhere in the report, it would be helpful to clearly display in a comparative sense the differences between permeability levels of 10^{-7}, 10^{-11}, 10^{-6}, and 10^{-2} with respect to thickness of material and distance that fluid will move in a given period of time. Since the Commission policy statement only specifies that any leak will be detected and that correction and cleanup can occur before there is a release to the environment from the boundary of the last liner, a better understanding of how fast material will move and how far will give the Commission information needed to make the ultimate policy judgment on the specific leak detection and permeability criteria necessary in the rules.

Definitions were provided on page 34 for various terms used for "geo" materials. It would be helpful if this were provided prior to the first significant discussion of these materials which begins shortly after page 15. It would also be helpful to put the definitions in terms that a lay person would better understand and visualize. Examples of typical dimensions or use situations may be helpful.

Page 25 Some additional clarification or discussion of methods for placement of materials on the top FML so as to prevent puncture would be helpful. References were made on previous pages to "sequenced ore loading" and a properly designed solution recovery system (leachate collection system) placed between the top liner and the ore. Discussion to tie the significance and importance of these items together would be helpful.

Page 29 In the third paragraph, the second sentence reads: "The leak detection system's permeable material component effectively serves as a liner system component....." This seems to need some clarification.

Page 31 The report notes the importance of preventing drying of the clay liner until the secondary liner or other appropriate materials can be placed over it to retard loss of moisture. The purpose is to prevent desiccation cracking which adversely affects the overall permeability of the liner. Assuming moisture is maintained until the secondary liner is in place, what is the likelihood of drying and desiccation cracking occurring over an extended period of time? Is there any information available on this issue?

Page 42 Reference is made in the 5th line down to ...the overlying secondary and underlying bottom liners... It seems in this situation that the "overlying secondary" is really the top or primary liner. The identification of liner components using the terms primary, secondary, top, bottom, is at times not consistent.

Pages 47-49 -- It would be helpful to be more explicit as to how the liner systems are consistent with the EQC policy. (See general comment above.)

Page 65 and Table 2-5 -- The information provided in the table regarding other state requirements for liners presents an obvious question regarding the real difference between permeabilities for liners of 10^{-5}, 10^{-6}, and 10^{-7}. Addressing the earlier comment regarding this issue would help to put some perspective on the differences.

Figure 2-8 -- This figure presents alternative liner configurations that are potentially capable of meeting the EQC policy requirements. The configurations are general, and specifications are minimal. One would assume that there are real differences between these liner configurations with regard to the risk of release, the degree of certainty that they would satisfy the Commission policy, etc. The prior analysis of liner components provides some basis for the reader to make subjective judgments of the relative performance characteristics of these liner configurations. There is insufficient information, however, to leave the reader comfortable that each liner would indeed meet the Commission policy within some limits of certainty. Some further explanation seems appropriate.

Section 3

Pages 80-81 -- All references to avian mortality and WAD cyanide levels should be eliminated from this report. This crosses into policy discussion which is specifically outside the scope of work specified in the contract. Discussion should focus on technology for removal and reuse of cyanide, and the cyanide levels that can be achieved with such technology.

Page 81 DEQ would not agree with the conclusion that "Reuse of cyanide in and of itself would not reduce the immediate or long term toxicity potential..." Reuse would be consistent with the intent of Oregon's Toxic Use Reduction Law. Reuse would reduce the quantity of chemicals transported onto the site during the life of operations, and would therefore reduce the potential for accidental release during transport, storage, handling, etc. If cyanide is removed, but not reused, it would have to go somewhere. The options would appear to be to transport it off site to another location for use or destruction and disposal, or to chemically convert it to a less toxic form for disposal on site. Either option would not be consistent with the Commission policy to reduce the potential for release to the greatest degree practicable.

Page 88 At the end of the page, the statement is made that "Heavy metals are also effectively removed." The term removed is not used consistently in the report. It would seem that removed would apply to "physically separated" and should not be used to refer to alteration of chemical form to a less soluble and less mobile form. If there is actual physical removal of heavy metals, where do they go? How are they to be handled and disposed of?

Page 92 and Section 4 -- Natural degradation should be taken advantage of during the life of the mine, before closure of the heap and tailings pond. Natural degradation is not very controllable or manageable. TRC correctly points out that it should not be considered an effective stand-alone technology.

Section 4

Pages 99-101 Section 4.3

- 4.3.1 - TRC states that a heap can be effectively detoxified.

- 4.3.2 - TRC states that covering would generally be beneficial, reducing water infiltration into the heap, thus inhibiting mobilization of metals, reducing potential for acid formation, and enhancing stability of the heap by reducing the potential for fluid buildup in the heap. TRC notes that a disadvantage of cover would be to reduce the potential for further natural degradation of residual cyanide left in the heap.

- 4.3.3 - TRC states that detoxification will virtually eliminate free and WAD cyanide and will stabilize metal release, and that covering will provide no additional benefit and may in fact be deleterious to the detoxification attributes (provided that the ore does not contain metals or acid generating constituents such as sulfides, in which cases cover may be desirable). TRC further states that cover would generally not be warranted since provisions for drainage of waters from the heap could be implemented to insure that water buildup and stability problems do not occur.

The conclusions in these sections appear inconsistent. If the heap can be effectively detoxified, then the identified disadvantages associated with cover (reduced further natural degradation) would be largely negated, and the positive aspects of cover (reduced infiltration, inhibited mobilization of metals, enhanced stability of the heap) would be realized.

The suggested implementation of drainage of the heap to protect against water buildup (as opposed to cover) implies a potential need for treatment of drainage water, (particularly if detoxification is not uniformly effective throughout the heap) and continued monitoring of drainage water quality after closure. This approach seems inconsistent with the general intent of closure in a manner to reduce the need for ongoing maintenance to zero as soon as practicable, and prevention of the release of potentially toxic chemicals to the environment.

Pages 101-102 Section 4.4

In 4.4.3, TRC states that once detoxified, a cover designed to exclude air and water may provide little, if any quantifiable benefit with respect to toxicity release. The section goes on to note qualifications that the tails do not possess the potential for acid generation, heavy metals species have been removed from the system, and drainage is implemented as necessary to prevent fluid buildup.

We would note that removal of heavy metals species from the tailings is not required by the current rule draft. It would seem that a closed, uncovered tailings facility would present a long term potential for production of leachate drainage that would require maintenance and monitoring, could require treatment, and would likely be inconsistent with the Commission policy regarding release to the environment of toxic chemicals.

Page 104 The conclusions of section 4.5.3 again appear to be based on an assumption that drainage is provided to prevent fluid buildup in the tailings. We have the same comments and concerns as expressed above on this issue.

Section 1

This section presents significant concerns. The conclusions section (1.3) should be deleted from this report in its entirety. If TRC wishes to make policy suggestions to the Commission, it may do so by letter addressed to the Commission. The scope of work in this contract specifically asks for technical response to specific questions and specifies that the consultant is not to cross the line into policy.

The conclusion at the top of page 7 regarding avian mortality should be deleted. It is not appropriate for the scope of work for this contract.

DEQ would recommend that TRC consider deleting the Record of Findings (Section 1.2) and rename Section 1.0 from Executive Summary to Introduction. There is substantial information within the body of the report, and it is virtually impossible to adequately capture it in a few bullets in an executive summary. Further, an attempt to summarize has the risk of crossing the line into policy matters.

APPENDIX C-1

ODEQ REQUEST FOR PROPOSAL

State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

REQUEST FOR PROPOSALS
FOR
TECHNICAL ADVICE ON MINING RULES

February 7, 1992

TABLE OF CONTENTS

ATTACHMENTS

I. GENERAL INFORMATION

A. Introduction

The Environmental Quality Commission (Commission) is considering adoption of rules to require mining operations using cyanide or other toxic chemicals to protect soils, groundwater, surface waters, and wildlife from contamination or harm by process solutions and waste waters. The protective measures required by the proposed rules include cyanide recovery and re-use, chemical detoxification of cyanide residues, and extensive lining and engineered closure of waste disposal facilities.

During the public participation process on the proposed rules, mining companies and associations have argued that some of the requirements are unnecessarily stringent or are unproven or are unavailable. Environmental protection organizations have argued that the proposed rules may not be adequately protective in certain respects.

The Commission has studied the proposed rules and the public comments received, and has extensively debated the policy issues associated with the rule proposal. Prior to final action to adopt proposed rules, the Commission has elected to seek an evaluation and advice on specific technical questions from an independent, knowledgeable contractor.

The entire record of the rulemaking proceeding is available for inspection as background material for this proposal request. The record can be reviewed in the headquarters office of the Department of Environmental Quality (DEQ or Department or Agency). A full copy of the draft proposed rules being considered by the Environmental Quality Commission is attached as Attachment B.

B. Proposed Project Timeline

Date	Action
February 7, 1992	Mail Request for Proposal
February 28, 1992	Information Exchange (to take place only between mailing of the RFP and this date)
March 10, 1992	Written Proposals Due
March 20, 1992	Selection of Contractor (written notice of award to successful proposer)

March 30, 1992	Protest Period (protests must be filed by this date)
April 10, 1992	Execution of Standard State Personal Service Contract (target date)
Within 15 calendar days of Contract Execution:	Participate in Public Meeting.
Within 45 calendar days of Contract Execution:	Draft Written Report submitted to DEQ.
Within 15 calendar days of Receipt of Comments from DEQ:	Submit Final Report.

C. <u>Services Requested</u>

DEQ is requesting proposals from individuals acting as independent contractors (see attached Independent Contractor Certification Statement form), firms, joint ventures or teams for providing advice to the Commission on technical issues related to proposed rules for mining operations using chemicals to extract metals from ores. Companies interested in pooling their resources through contractor/subcontractor, joint ventures or team arrangements can do so provided that one entity is identified which ultimately will bear total contract responsibility.

D. <u>Scope of Work</u>

Three policies have been established by the Commission. The selected contractor shall evaluate and address specific technical questions surrounding these policies. The Commission is <u>not</u> asking for alternative policy recommendations or evaluation of economic issues. The task of the contractor is to answer the questions posed in the following paragraphs based on their knowledge, expertise, experience, review of current published technical data, and technical evaluation of the issues.

1. <u>Questions on Liners, Leak Detection, and Leak Collection Systems</u>

   a. <u>Statement of Policy</u>:

   The Commission establishes as policy that a liner, leak detection and leak collection system are necessary to assure that any leak will be detected before toxic materials escape from the liner system and are released to the environment. These systems must assure that if a leak is found, sufficient time is available to allow for the repair of the leak and clean up of any leaked material before there is a release to the environment. Natural conditions, such as depth to groundwater or net rainfall, shall be considered as additional protection but not in lieu of the protection required by the required engineered protection.

NOTE: Definition of "environment" or use of defining qualifiers is central to the issue. The Commission considers that the environment begins at the bottom of the last liner.

b. Issue:

In the proposed rule contained in 340-43-065(4), the requirements for heap leach pad liners are as follows:

(4) The heap leach pad liner system shall be of triple liner construction with between liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible membrane middle and top liners of suitable synthetic material separated by a minimum of 12 inches of permeable material (minimum permeability of 10^{-2} cm/sec);

(c) A leak detection system between the synthetic liners capable of detecting leakage of 400 gallons/day acre within ten weeks of leak initiation.

As opposed to this liner system, the Oregon Mining Council has proposed a liner characterized either as a composite liner or as a double liner and generally described as follows:

Composite Liner -- a composite liner system construction with between liner leak detection consisting of:

- An engineered, stable, low-permeability soil/clay bottom liner (maximum coefficient of permeaability of 10^{-7} cm/sec) with a minimum thickness of 12 inches;
- Continuous flexible membrane top liner of suitable synthetic material;

- A geotextile layer between the liner materials for leak detection. The leak detection and recovery system would also include collector pipes tied to the geotextile, spaced at appropriate intervals to achieve the 10-week leak initiation detection performance standard.

c. Question:

Will either or both liner systems meet the stated policy objective of the Commission?

d. Method to Answer or Address Question:

(1) Are each of the various liner systems proposed technically feasible?

(2) Will each of the various liner systems meet the stated Commission policy?

(3) For those liner systems which will meet the stated Commission policy, what level of certainty for achieving this policy do you assign to each system?

(4) Are there other liner systems which will achieve this policy and what level of certainty for achieving this policy do you assign to each?

The consultant is also asked to provide a simple comparison of typical costs for installation of the various liner configurations.

2. Questions on Tailings Treatment to Reduce the Potential for Release of Toxics

a. Statement of Policy:

The Commission establishes as policy that the toxicity and potential for long-term cyanide and toxic metals release from mill tailings should be reduced to the greatest degree practicable through tailings treatment.

b. Issue:

The proposed rules in 340-43-070(1) state the following:

(1) Mill tailings shall be treated by cyanide removal and re-use prior to disposal to reduce the amount of cyanide introduced into the tailings pond. Chemical oxidation or other means shall be additionally used, if necessary, prior to disposal to reduce the WAD cyanide level in the

liquid fraction of the tailings. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak-acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm.

The rules do not require removal of potentially toxic metals from tailings prior to placement in the tailings pond. The rules do require steps to control acid formation in the tailings pond and require covering upon closure with a composite cover designed to prevent water and air infiltration.

c. Question:

Do the requirements for **removal** and **reuse** of cyanide materially reduce toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

d. Method to Answer or Address Question:

(1) Are **removal** and **reuse** technically feasible?

Potential factors for consideration include:

- Is the process technically defined and understood?
- Has the process been demonstrated in practical application, and if so, where?
- Are engineering firms available to design and oversee construction?
- Are materials and equipment available to construct?

(2). Do **removal** and **reuse** (evaluated separately) materially reduce the toxicity and potential for long-term cyanide and toxic metals release from mill tailings?

(3) What is the level of certainty you give to the answers provided above?

(4) Are there other tailings treatment technologies which will equally, or more effectively achieve the policy of the Commission?

3. Questions on Closure of the Heap Leach and Tailings Facilities

a. Statement of Policy:

The Commission establishes as policy that the closure of the heap leach and tailings disposal facilities will prevent release to the environment of toxic chemicals contained in the facility.

b. Issue:

Rule 340-43-080(4)(a), as proposed, requires that the heap shall be "... detoxified over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The WAD cyanide concentration in the rinsate shall be no greater than 0.2 ppm."

In 340-43-080(4)(b), the proposed rules require that the closure of the heap shall be "... by covering the heap with a cover designed to prevent water and air infiltration."

In 340-43-080(5), the proposed rules state that "The tailings disposal facility shall be closed by covering with a composite cover designed to prevent water and air infiltration and be environmentally stable for an indefinite period of time."

c. Question:

Do the requirements of detoxification (cyanide removal by rinsing) of the heap and covering of the heap and tailings facility to exclude air and water materially reduce the likelihood of any release to the environment of toxic chemicals and metals contained in the heap over the long term?

d. Method to Answer or Address Question:

(1) Are detoxification and covering (as prescribed in this rule) technically feasible?

(2) Do detoxification and covering (evaluated separately and together) materially reduce the likelihood of a release of toxic chemicals and metals to the environment?

(3) What is the level of certainty you give to the answers provided above?

(4) Are there other technologies which can equally or more effectively achieve the policy of the Commission?

4. Public Meeting

In addition to answering the above questions, the selected contractor will be expected to participate in a meeting with persons who have expressed an interest in the rulemaking proceeding by presenting testimony at public hearings. The purpose of this meeting will be to:

- Inform the interested public on the contractors approach and schedule for addressing the questions posed.

- Identifying any anticipated need to contact persons who presented testimony in the proceeding for additional information to assist in addressing the questions posed. The Commission expects an open process where all interested parties will have the opportunity to attend the meeting.

This meeting will be scheduled at a time and place mutually agreeable to DEQ and the selected contractor. DEQ will arrange the meeting and provide notice to interested parties.

5. Written Report

A written report shall be submitted as the final product of this contract. The report shall state the question being answered, summarize the methodologies for evaluating and responding to the question, and clearly state the results of the evaluation and answer given.

A draft report shall be submitted to the Department for review. The Department will provide written comments to the contractor. The contractor will then complete the report and file a single master copy, ready for reproduction, with the Department. The report shall become the property of the Department. The Department may copy and distribute the report as it deems appropriate.

E. Type of Contract

DEQ anticipates awarding a fixed price contract. The State of Oregon standard personal service contract will be signed.

DEQ will, in its sole discretion, reserve the right to renew the contract.

F. Payment Procedure

Payment schedules for any contract entered into as a result of the RFP will be mutually agreed upon by DEQ and the prime contractor.

G. <u>Managing Conflict of Interest</u>

Proposing contractors (including subcontractors) shall disclose any potential conflicts of interest. A potential conflict of interest includes, but is not limited to, any involvement during the past five years with mining companies, mining industry groups, or environmental groups active in working on mining regulations and permitting or holding any interest in property in Oregon that may have mineral development potential. During the proposal development period and, if awarded the contract, during the contract period, the selected contractor shall maintain an arm's length relationship with all parties who are or could be interested in the rule making procedure before the Commission. The selected contractor is required to disclose all contacts, either to or by them, during the proposal process and the life of the contract.

APPENDIX C-2

ODEQ PROPOSED RULE DRAFT

RULES PROPOSAL:

OREGON ADMINISTRATIVE RULES

CHAPTER 340

DIVISION 43

CHEMICAL MINING

GUIDELINES FOR THE DESIGN, CONSTRUCTION, OPERATION AND CLOSURE OF CHEMICAL MINING OPERATIONS

OAR 340-43-065	Guidelines for Design, Construction, and Operation of Heap-Leach Facilities
OAR 340-43-070	Guidelines for Disposal of Mill Tailings
OAR 340-43-075	Guidelines for Disposal or Storage of Wasterock, Low-Grade Ore and Other Mined Materials
OAR 340-43-080	Guidelines for Heap-Leach and Tailings Disposal Facility Closure
OAR 340-43-085	Post-Closure Monitoring
OAR 340-43-090	Land Disposal of Wastewater
OAR 340-43-095	Guidelines for Open-Pit Closure

PURPOSE

340-43-005

The purpose of these rules and guidelines is to protect the quality of the environment and public health in Oregon by requiring application of "... all available and reasonable methods...", Oregon Revised Statutes (ORS) 468.710, for control of wastes and chemicals relative to design, construction, operation, and closure of mining operations which use cyanide or other toxic chemicals to extract metals or metal-bearing minerals from the ore and which produce wastes or wastewaters containing toxic materials.

DEFINITIONS

340-43-010

Unless the context requires otherwise, as used in this Division:

(1) "Chemical process mine" means a mining and processing operation for metal-bearing ores that uses chemicals to dissolve metals from ores.

(2) "Department" means the Department of Environmental Quality.

(3) "Guidelines" means this body of rules contained in 340-43-045 through 340-43-100.

(4) "Positive exclusion of wildlife" means the use of such devices as tanks, pipes, fences, netting, covers and heap-leach drip-irrigation emitters or covered emitters.

(5) "Tailings" means the spent ore resulting from the milling and chemical extraction process.

PERMIT REQUIRED

340-43-015

(1) A person proposing to construct a new chemical mining operation, commencing to operate an existing non-permitted operation, or proposing to substantially modify or expand an existing operation shall first apply for, and receive, a permit from the Department. The permit may be an NPDES (National Pollutant Discharge Elimination System) permit if there is a point-source discharge to surface waters or a WPCF (Water Pollution Control Facility) permit if there is no discharge. Consideration may be given to site-specific conditions such as climate, proximity to water, and type of wastes to establish the final permit type and requirements for the facility.

(2) The permit application shall comply with the requirements of OAR Chapter 340, Divisions 14 and 45 and be accompanied by a report that fully addresses the requirements of this Division .

PERMIT APPLICATION

340-43-020

(1) The permit application shall fully describe the existing site and environmental conditions, with an analysis of how the proposed operation will affect the site and its environment. The Department shall, at a minimum, require the information specified for the DOGAMI consolidated application under Section 13, Chapter 735, 1991 Oregon Laws. The Department will also use the information contained in NEPA (National Environmental Policy Act), EA (Environmental Assessment), or EIS (Environmental Impact Statement) documents, if they are required by the project, as partial fulfillment of the requirements of this paragraph.

(2) The permit application shall, in addition to the information described in Paragraph (1) above, include the following information, unless the information has been otherwise submitted:

(a) Climate/meteorology characterization, with supporting data;

(b) Soils characterization, with supporting data;

(c) Surface water hydrology study, with supporting data;

(d) Characterization of surface water and groundwater quality;

(e) Inventory of surface water and groundwater beneficial uses;

(f) Hydrogeologic characterization of groundwater, with supporting data;

(g) Geologic engineering, hazards and geotechnical study, with supporting data;

(h) Characterization of mine materials and wastes which include, for example, overburden, waste rock, stockpiled ore, leached ore and tailings. Characterization of mine materials and wastes shall include, but not be limited to the following:

(A) Chemical and mineral analysis related to toxicity;

(B) Determination of the potential for acid water formation;

(C) Determination of the potential for long-term leaching of toxic materials from the wastes;

(i) Characterization of wastewater (quantity and chemical and physical quality) produced by the operation;

(j) Assessment of the potential for acid-water formation from waste disposal facilities, low-grade ore stockpiles, waste rock piles and for surface water or groundwater accumulation in open pits that will remain after mining is ended.

(3) Data submitted by the permit applicant should be based on analysis of the actual materials, when possible, or may be based on estimates from knowledge of similar operations and professional judgment.

PLANS AND SPECIFICATIONS

340-43-025

(1) A person constructing or commencing to operate a chemical process mine or substantially modifying or expanding an existing chemical process mine shall first submit plans and specifications to the Department for construction, operation and maintenance of the facilities intended for treatment, control and disposal of wastes.

(2) The Department shall approve the plans, in writing, before construction of the facilities may be started. The plans shall address all applicable requirements of this Division and shall include, but not be limited to, the following:

(a) A description of the facilities to be constructed, including tanks, pipes and other storage and conveyance means for processing chemicals and solutions and wastewaters;

(b) A management plan for control of surface water;

(c) A management plan for treatment and disposal of excess wastewater, including provisions for reuse and wastewater minimization;

(d) A facility construction plan including, as applicable, the design of low-permeability soil barriers, the type of geosynthetics to be used and a description of their installation methods, the design of wastewater treatment facilities and processes, a quality assurance plan for applicable phases of construction and a listing of construction certification reports to be provided to the Department;

(e) A preliminary closure plan;

(f) A preliminary post-closure monitoring and maintenance plan;

(g) A spill containment and control plan.

DESIGN, CONSTRUCTION, OPERATION AND CLOSURE REQUIREMENTS

340-43-030

(1) All chemical process and waste disposal facilitiesand facilities for mixing, distribution, and application of chemicals associated with on-site mining operations; ore preparation and beneficiation facilities; and processed -ore

disposal facilities shall be designed, constructed, operated and closed in accordance with the guidelines contained in this Division.

(2) A groundwater monitoring plan shall be submitted to, and be approved by the Department. Monitoring wells shall be installed for detection of groundwater contamination as required by OAR Chapter 340, Division 40, unless the hydrogeology of the site or other technical information indicates that an adverse impact on groundwater quality is not likely to occur.

(3) Alternative methods of control of wastes may be acceptable if the permit applicant can demonstrate that the alternate methods will provide fully-equivalent environmental protection. The burden of proof of fully-equivalent protection lies with the permit applicant.

(4) The Department may, in accordance with a written compliance schedule, grant reasonable time for existing facilities to comply with these rules.

EXEMPTION FROM STATE PERMIT FOR HAZARDOUS WASTE TREATMENT OR DISPOSAL FACILITIES

340-43-035

(1) The state hazardous waste program requires a permit for the "treatment", "storage" or "disposal" of any "hazardous waste" as identified or listed in OAR Chapter 340, Division 101 from the Department, prior to the treatment and disposal of wastes. Permitting requirements can be found in OAR Chapter 340, Division 105, Hazardous Waste Management.

(2) However, any operation permitted under this Division, which would otherwise require the neutralization or treatment of hazardous waste and would require a permit pursuant to OAR Chapter 340, Division 105, shall be exempt from the requirement to obtain such hazardous waste treatment permit.

(3) All mined materials disposed of under this Division shall pass Oregon's hazardous waste rule criteria or they will be considered a state hazardous waste and must be disposed of accordingly.

GUIDELINES FOR THE DESIGN, CONSTRUCTION, OPERATION AND CLOSURE OF CHEMICAL MINING OPERATIONS

PURPOSE

340-43-040

(1) This Division establishes criteria for the design, construction, operation and closure of chemical mining operations and supplements the provisions of OAR 340-43-005 through OAR 340-43-035.

(2) Any disapproval of submitted plans or specifications, or imposition of requirements by the Department to improve existing facilities or their operation will be referenced when appropriate, to applicable guidelines or rules.

GENERAL PROVISIONS

340-43-045

(1) Facilities permitted under either a WPCF or NPDES permit shall not discharge wastewater or process solutions to surface water, groundwater or soils, except as expressly allowed by the permit.

(2) Facilities subject to these rules shall not be sited in 100-year floodplainsor wetlands. A buffer zone (a minimum of 200 feet wide) shall be established between waste disposal facilities and surface waters.

(3) All chemical conveyances (ditches, troughs, pipes, etc.) shall be equipped with secondary containment and leak detection means for preventing and detecting release of chemicals to surface water, groundwater or soils.

(4) Acid water accumulation in open pits resulting from the mining operation must be prevented by appropriate mining practices, by measures taken in the closure process, or be treated to control pH and toxicity, for the life of the pit.

(5) Construction of surface impoundment liner systems shall conform generally to the principles and practices described in <u>EPA/600/2-88/052, Lining of Waste Containment and Other Impoundment Facilities, September 1988</u>.

(6) The Department may require the permittee to hire a third-party contractor to perform the functions set forth below. Selection of the contractor shall be subject to Department approval.

(a) Review and evaluate the design and construction specifications of all mined-materials disposal facilities permitted under this Division for functional adequacy and conformance with Department requirements. The Department shall not approve construction of the disposal facilities until the design and construction specifications have been evaluated.

(b) Monitor the course of construction of all mined-materials disposal facilities for compliance with the approved design and construction specifications. The third-party contractor shall regularly document the progress of construction and the Department shall require the permittee to take corrective action if construction does not satisfactorily conform to the approved design and construction specifications.

CONTROL OF SURFACE WATER RUN-ON AND RUN-OFF

340-43-050

(1) Surface water run-on and run-off shall be controlled such that it will not endanger the facility or become contaminated by contact with process materials or loaded with sediment. The control systems shall be designed to accommodate a 100-year, 24-hour storm event, or any other defined climatic event that is more appropriate to the site, and be placed so as to allow for restoration of the natural drainage network, to the maximum extent practicable, upon facility closure.

(2) All mined materials shall be properly placed and protected from surface water and precipitation so as not to be eroded and contribute sediment to site stormwater run-off or to otherwise contaminate surface water.

PHYSICAL STABILITY OF RETAINING STRUCTURES AND EMPLACED MINE MATERIALS

340-43-055

(1) Permit applicants must demonstrate to the Department that the design of chemical processing facilities and waste disposal facilities is adequate to ensure the stability of all structural components of the facilities during operation, closure and post closure.

(2) Retaining structures, foundations and mine materials emplacements shall be designed by a qualified, registered professional and be constructed for long-term stability under anticipated loading and seismic conditions.

(3) Temporary structures and materials emplacements may, with written approval from the Department, be constructed to a lesser standard if it can be shown that they pose no, or minimal, threat to public safety or the environment.

PROTECTION OF WILDLIFE

340-43-060

(1) Wildlife shall be positively excluded from contact with chemical processing solutions and wastewaters containing chemicals.

(2) The Department may waive the positive exclusion requirement if the Oregon Department of Fish and Wildlife (ODF&W) certifies to the Department that the project is designed such that it will adequately protect wildlife.

GUIDELINES FOR DESIGN, CONSTRUCTION, AND OPERATION OF HEAP-LEACH FACILITIES

340-43-065

(1) This paragraph applies to heap-leach facilities using dedicated, or expanding, pads. Heap-leach facilities using on-off, reusable pads may require variations from these rules; they shall be approved on a case-by-case basis by the Department.

(2) The heap-leach facility (pad and associated ponds, pipes and tanks) shall be sized to prevent flooding of any of its components.

(3) TABLE 1 of this Division establishes minimum capacity-sizing criteria for the leach-pad and ponds. The pad and ponds may be designed to act separately or in conjunction with each other to obtain the required storage volumes. Other design criteria may be used, with Department approval, if local conditions warrant. The best available climatic data shall be used to confirm the critical design storm event and estimate the liquid levels in the system over a full seasonal cycle. The liquid mass balance may include provision for evaporation.

(4) The heap-leach pad liner system shall be of triple liner construction with between-liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible-membrane middle and top liners of suitable synthetic material separated by a minimum of 12 inches of permeable material (minimum permeability of 10^{-2} cm/sec);

(c) A leak-detection system between the synthetic liners capable of detecting leakage of 400 gallons/day-acre within ten weeks of leak initiation.

(5) The processing-chemical pond liners shall be of triple liner construction with between-liner leak detection consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10^{-7} cm/sec) with a minimum thickness of 36 inches;

(b) Continuous flexible-membrane middle and top liners of suitable synthetic material separated by a permeable material (minimum coefficient of permeability of 10^{-2} cm/sec);

(c) A leak detection system between the synthetic liners capable of detecting leakage of 400 gallons/day-acre, within ten weeks of leak initiation.

(6) Emergency ponds may be constructed as an alternative to larger pregnant and barren ponds. The emergency pond may be constructed to a lesser standard, with the limitation that it is to be used only infrequently and for short periods of time. The Department will specify reporting and use limitations for the ponds in the permit. A between-liner leak detection system is not required for the emergency pond.

(7) The emergency-pond liner shall be of composite construction consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10^{-6} cm/sec) with a minimum thickness of 12 inches, and

(b) A single flexible-membrane synthetic top liner of suitable material.

(6) The heap-leach pad shall be provided with a process chemical collection system above the upper-most liner that will prevent an accumulation of process chemical within the heap greater than 24 inches in depth.

(7) The permittee shall prepare a written operating plan for safe temporary shut-down of the heap-leach facility and train employees in its implementation.

(8) The permittee shall respond to leakage collected by the heap-leach and processing-chemical storage pond leak-collection systems according to the process defined in TABLE 2.

(9) The permittee shall determine the acid-generating potential of the spent ore by acid\base accounting and other appropriate static and dynamic laboratory tests. If the spent ore is shown to be potentially acid generating under the conditions expected in the heap at closure, the permittee shall submit a plan for acid correction for Department approval prior to loading the heap.

GUIDELINES FOR DISPOSAL OF MILL TAILINGS

340-43-070

(1) Mill tailings shall be treated by cyanide removal and re-use prior to disposal to reduce the amount of cyanide introduced into the tailings pond. Chemical oxidation or other means shall be additionally used, if necessary, prior to disposal to reduce the WAD cyanide level in the liquid fraction of the tailings. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak-acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm.

(2) (Deleted)

(3) The permittee shall determine the potential for acid-water formation from the tailings by means of acid-base accounting and other suitable laboratory static and dynamic tests. If acid formation can occur, basic materials shall be added to the tailings in the amount of three (3) times the acid formation potential or to give a net neutralization potential of at least 20 tons of $CaCO_3$ per 1000 tons of tailings, whichever is greater, before placing tailings in the disposal facility.

(4) The disposal facility shall be lined with a composite double liner consisting of a flexible-membrane synthetic top liner in tight contact with an engineered,

stable, soil/clay bottom liner (maximum coefficient of permeability of 10^{-7} cm/sec) having a minimum thickness of 36 inches.

Construction of the liner shall generally follow the principles and practices contained in EPA/600/2-88/052, "Lining of Waste Containment and Other Impoundment Facilities, September, 1988.

(5) The disposal facility shall be provided with a leachate collection system above the liner suitable for monitoring, collecting and treating potential acid drainage.

GUIDELINES FOR DISPOSAL OR STORAGE OF WASTEROCK, LOW-GRADE ORE AND OTHER MINED MATERIALS

340-43-075

The permittee shall determine the acid-producing and metals-release potential of the wasterock, low-grade ore or other mined materials by acid/base accounting and other appropriate static and dynamic laboratory tests. If the mined materials are shown to be potentially acid forming, or capable of releasing toxic metals, the permittee shall submit a plan for correction and disposal for Department approval prior to permanently placing the materials.

GUIDELINES FOR HEAP-LEACH AND TAILINGS DISPOSAL FACILITY CLOSURE

340-43-080

(1) The waste disposal facilities shall be closed under these rules in conjunction with the reclamation requirements of DOGAMI (Oregon Department of Geology and Mineral Industries).

(2) An up-dated closure plan and post-closure monitoring and maintenance plan shall be submitted to the Department by the permittee at least 180 days prior to beginning closure operations or making any substantial changes to the operation. The closure plan must be compatible with DOGAMI's reclamation plan and may be part of it.

(3) Chemical conveyances (ditches, troughs, pipes, etc.) not necessary for post-closure monitoring shall be removed. The secondary containment systems shall be checked before closure for process-chemical contamination, and contaminated soil or other materials, if any, shall be removed to an acceptable disposal facility.

(4) Closure of the heap-leach facility.

(a) The heap shall be detoxified over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The WAD cyanide concentration in the rinsate shall be no greater than 0.2 ppm.

(b) Following detoxification as defined in (a) above, the heap shall be closed in place on the pad by covering the heap with a cover designed to prevent water and air infiltration. The cover should consist, at a minimum, of a low-permeability layer and suitable drainage and soil layers to prevent erosion and damage by animals and to sustain vegetation growth, in accordance with DOGAMI's reclamation rules.

(c) The ponds associated with the heap shall be closed by folding in the synthetic liners and filling and contouring the pits with inert material. Residual sludge may be disposed of in one of the on-site waste disposal facilities, provided it meets the criteria for such wastes in these guidelines. The process chemical collection system of the heap shall be maintained in operative condition so that it can be used to monitor the amount and quality of infiltrated water, if any, draining from the heap.

(5) The tailings disposal facility shall be closed by covering with a composite cover designed to prevent water and air infiltration and be environmentally stable for an indefinite period of time. Maximum effort shall be made to isolate the tailings from the environment. Construction of the cover shall generally follow the principles and practices contained in EPA/530-SW-89-047, Technical Guidance Document -- Final Covers on Hazardous Waste Landfills and Surface Impoundments.

POST-CLOSURE MONITORING

340-43-085

(1) The Department may continue its permit in force for thirty (30) years after closure of the operation and will include permit requirements for periodic monitoring to determine if release of pollutants is occurring.

(2) Monitoring data will be reviewed regularly by the Department to determine the effectiveness of closure of the disposal facilities. The Department will consult with DOGAMI on release of security funds that would otherwise be needed to correct problems resulting from ineffective closure.

LAND DISPOSAL OF WASTEWATER

340-43-090

(1) To qualify for land disposal of excess wastewater, the permit applicant shall demonstrate to the Department that the process has been designed to minimize the amount of excess wastewater that is produced, through use of water-efficient processes, wastewater treatment and reuse, and reduction by natural evaporation. Excess wastewater that must be released shall be treated and disposed of to land under the conditions specified in the permit.

(2) A disposal plan shall be submitted as part of the permit application that, at a minimum, includes:

(a) Wastewater quantity and quality characterization;

(b) Soils characterization and suitability analysis;

(c) Drainage and run-off characteristics of the site relative to land application of wastewater;

(d) Proximity of the disposal site to groundwater and surface water and potential impact;

(e) Wastewater application schedule and water balance;

(f) Disposal site assimilative capacity determination;

(g) Soils, surface water and groundwater monitoring plan;

(h) Potential impact on wildlife or sensitive plant species.

(3) The Department will evaluate the disposal plan and set site-specific permit conditions for the wastewater discharge.

GUIDELINES FOR OPEN-PIT CLOSURE

340-43-095

(1) Open pits that will be left as a result of the mining operation shall be assessed prior to, and following, mining operations for the potential to contaminate

water to the extent that it might not meet water-quality standards due to build-up of acid or toxic metals.

(2) If the Department finds that the potential for water accumulation in the pit(s) exists, the permit applicant shall submit a closure plan for the pit that will address contamination prevention and possible remedial treatment of the water. The closure plan shall, at a minimum, examine the following alternatives:

(a) Avoidance, during mining, of acid-generating materials that can be left in place, rather than being exposed to oxidation and weathering;

(b) Removal from the pit and disposal, during or after the mining operation, of residual acid-generating materials that would otherwise be left exposed to oxidation and weathering;

(c) Protective capping in-situ of residual acid-generating materials;

(d) Treatment methods for correcting acidity and toxicity of accumulated water;

(e) Installation of an impermeable liner under ponded water to prevent groundwater contamination;

(f) Backfilling of the pit(s) above the water table to reduce oxidation of residual acid-generating materials.

TABLE 1

Heap-Leach Liquid Storage Criteria

Component	Pregnant-Solution Pond	Barren-Solution Pond
Operating Volume	Minimum necessary to maintain recirculation	Minimum necessary to maintain recirculation
Operational Surge	Anticipated draindown and rinse volume	Anticipated draindown and rinse volume
Climatic Surge	100-yr, 24-hr storm plus 10-yr snowmelt	100-yr, 24-hr storm plus 10-yr snowmelt
Safety Factor	2-ft dry freeboard	2-ft dry freeboard

TABLE 2

Required Responses to Leakage Detected from the Leach Pad

Leakage Category	Response
Zero leakage to 200 gal/day-acre	Notify the Department; increase pumping and monitoring
Leakage from 200 gal/day-acre to 400 gal/day-acre	Change operating practices to reduce leakage
Leakage in excess of 400 gal/day-acre	Repair leaks under Department schedule.

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