

FARO ABANDONMENT STUDY
COMMENTS ON DRAFT REPORT OF JULY 9, 1981

1. GENERAL

The report is comprehensive, well written, clear and understandable. Three separate alternative schemes are presented and one is recommended. There are some minor typographical errors in the report and there is some confusion about tenses. These should be tidied up and it should be made clear that the report is to Cyprus Anvil Mining Corporation and that it is presenting alternative abandonment schemes with a recommendation on the most suitable one..

2. TECHNICAL FEATURES OF THE RECOMMENDED ABANDONMENT RESERVOIR SCHEME

- a) The abandonment dam is designed to withstand the Maximum Credible Earthquake. The derived maximum credible earthquake and the design peak ground acceleration provide adequate safety against earthquake.
- b) The abandonment dam is designed to withstand the probable maximum flood. The derived design flood is adequately large.
- c) The flow-through rock fill dam design appears to be generally adequate and to incorporate most of the features found from experience to be desirable with this type of dam. However it will be necessary to exercise great care with the design and the supervision of construction of the interface between the flow-through section and the remainder of the dam, particularly at the crest. Otherwise erosion could occur, leading to eventual failure. Also care must be taken with the toe of the dam and it may be desirable to lower the toe such that it is always submerged. These features can be taken care of during the detailed design of the flow-through section, at which time it will probably be desirable to conduct model studies to aid the design.

6

However there is virtually no experience with this type of dam in an environment as cold as at Faro. It is conceivable that progressive glaciation could take place with the result that the water could eventually be forced to run down the face of the dam, in which case channelization of the flow, local erosion and eventual failure of the dam could occur. Winter performance should be checked out, as recommended in the report, with a small experimental flow-through dam section constructed and tested near the mine site. It should be done as soon as possible to allow adequate time to modify the design in the light of the experience gained.

- d) The concept of keeping the tailings submerged at all times and minimizing the seepage through the tailings appears to be a good one and represents the best chance of maintaining acceptable water quality downstream of the dam. Obviously there is considerable uncertainty about the amount of seepage and the chemical reactions. Clearly every effort should be made to place the tailings in such a way as to reduce seepage into the reservoir banks.
- e) The recommendation that no provision be made in the flow-through dam for fish passage appears to be sensible. Such provision could jeopardize the integrity of the dam.
- f) Proposals for the abandonment of other features such as the fresh water dam, the pumphouse diversions, etc appear to be satisfactory.

3. PROCEDURAL QUESTIONS

- a) It is recognized that Cyprus Anvil's mine at Faro has many years to run before it will be abandoned. In that time there may be many changes to the mine operating plan, the scope of the mining operation, development of new technology and so on. Nevertheless a large quantity of tailings will be accumulating and there will have to be a way of abandoning them in a safe and environmentally acceptable way. The proposed abandonment reservoir scheme appears generally satisfactory at this time. However the proposed scheme is costly. The abandonment "plan" (as distinct from an abandonment scheme) should include information on how it is to be funded. This information should be in sufficient detail that the Board can be assured that the proposed plan will be adequately funded and that it can be carried out when the time comes to abandon the mine.
- b) It could be that a combination of Schemes 2 and 3 would be more economical than Scheme 2.

4. SUMMARY

- a) The proposed abandonment scheme appears to be generally satisfactory from a technical point of view.
- b) Field experiments should be conducted to check on the performance of a flow-through dam under the climatic conditions prevailing at Faro.
- c) The tailings should be deposited in such a way as to minimize seepage from the tailings pond.
- d) The abandonment plan should include plans for funding the recommended scheme.

So Russell
July 29, 1981

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Comments on the Draft Klohn Leonoff
Report: Faro Abandonment Plan
Prepared by the Habitat Management
Division, Department of Fisheries & Oceans

Introduction

The Habitat Management Division has reviewed a draft of the final report: Faro Abandonment Plan prepared for Cyprus Anvil Mining Corporation by Klohn Leonoff Consultants Ltd. Unfortunately, because of the complicated nature of many aspects of the report and time constraints, it was impossible to undertake as though a review of the various proposals as potential environmental risks would dictate. Accordingly, although DFO has major concerns regarding the abandonment plan, a number of which are briefly discussed herein, many other concerns are not discussed. These latter topics include such items as potential waste rock leachates, disposal of potentially contaminated pit waters, and detailed review of the water chemistry model, and engineering discussions pertaining to hydrological aspects of the various schemes.

Before outlining our concerns with respect to the subject report, I think it is also appropriate to note that certain prior decisions have necessarily limited the number of options available for the final abandonment of the Cyprus Anvil Mine Tailings. We refer to the decision by the YTWB that Cyprus Anvil will be allowed to continue to deposit tailings in the Rose Creek Valley. This decision was apparently made despite DOE's recommendation that "In view of the long term environmental risks associated with the present proposal, a study of alternative tailings disposal sites should have been undertaken..." (DOE submission to the YTWB September 1980). This is further complicated by the need for Cyprus Anvil to commence using the expanded facilities by October, 1981.

Further to the above, because the abandonment plan will not be implemented prior to cessation of mining operations, we suggest that regardless of the abandonment scheme chosen at this time, continuing reassessment of abandonment options should be conducted during the lifetime of the mining operation.

With respect to the various schemes presented in the Klohn Leonoff Report, we offer the following comments:-

Scheme 1: Permanent Rose Creek Diversion Channel

We understand from the Klohn Leonoff Report that both the consultants and the YTWB mining sub-committee agree that this scheme is unacceptable at this time because of difficulties involved in construction of a maintenance-free diversion channel. We cannot comment on this aspect of the scheme since we have not reviewed any of the supporting engineering details used in arriving at this decision. However, it appears that the diversion proposal may be more promising than the cross valley dam in terms of water quality and should not, therefore, be entirely ruled out as an option. In this regard we recognize Klohn Leonoff's statement (page 37) that "...changes in the state of the art may result in Scheme 1 being accepted".

Scheme 2: Abandonment Reservoir

This is the option preferred by Klohn Leonoff Consultants and Cyprus Anvil Mining Corporation. Accordingly, we will provide more detailed comments on this scheme.

Water Quality Criteria

As noted in the Report (Appendix I) DFO has stipulated that the abandonment plan must provide assurances that:

- (i) The water quality in the reservoir is such that fish can utilize the lake on a year round basis
- (ii) The quality of water flowing over the dam, as well as that of seepage flow, is such that the fisheries resource in the river systems downstream from the dam will not be adversely affected.

Within the Klohn Leonoff Report there are a variety of other terms of references for the abandonment study as they pertain to water quality criteria. For example:

- (a) The Yukon Territorial Water Board, Mining Sub-Committee stipulated that "water quality after abandonment must meet existing water licence criteria" (p.6).
- (b) Table 3.7 (p.28) presents a summary of "Acceptable Zinc Concentrations for Rainbow Trout" which was used by the consultant in determining the environmental effects of projected zinc concentrations.
- (c) Table 3.8 (p.29) presents a comparison of CMC Licence standards, "Fisheries Guidelines" (extracted from Appendix VIII), Drinking Water Standards, and background Rose Creek Water Quality measurements, upstream and downstream of the mine site.

In light of the above water quality criteria, the Klohn Leonoff Report concludes (p.2) that:

"Water quality studies indicate that a minimum pH level of 7.2 and a maximum zinc level of 0.09 mg/l will be maintained in the pond. Downstream of the dam, a minimum pH level of 7.0 and a maximum zinc level of 0.2 mg/l is expected in Rose Creek... These levels are considered adequate for maintaining fish habitat both within the abandonment reservoir and downstream in Rose Creek".

In point form we have the following comments on the water quality aspects of this abandonment scheme:

1. DFO does not consider that the CMC licence requirements reflect adequate receiving water quality criteria necessary to support fish life. Contrary to the existing tailings disposal system wherein effluent is discharged to a receiving water environment (i.e. Rose Creek) the proposed abandonment scheme (reservoir and overflow/seepage) would in effect be the receiving water stream.

2. Table 3.6 (p.27)(below) appears to have been derived from a mathematical relationship between water hardness and zinc toxicity, in combination with an application factor for zinc ranging between 0.1 and 0.05.

Hardness (mg/l CaCO ₃)	96 hour LC 50 (mg/l)	Acceptable Zn Concentrations (mg/l)
250	5.32	0.27 - 0.53
100	1.92	0.10 - 0.19
75	1.40	0.07 - 0.14

In contrast the American Fisheries Society (1979) in a critique of the EPA Red Book (EPA, 1976) recommended the following criteria for total zinc in fresh water.

Hardness (mg/l CaCO ₃)	Zinc (Total) Criterion (mg/l)
0 - 75	0.050
75 - 150	0.050
150 - 300	0.10
300 - 400	0.30
>400	0.60

Using the results for predicted background water chemistry (Table VII-8) which indicates that hardness varies from 58-77 mg/l CaCO₃; May to November and 155 mg/l CaCO₃, December to January, zinc levels should not exceed 0.050 mg/l in the Rose Creek system according to the American Fisheries Society criteria.

3. Although the maximum predicted zinc concentration of 0.2 mg/l in Rose Creek below the reservoir corresponds to a period of maximum hardness (i.e. winter time) it is implied that this level is acceptable at this time of year based on Beak's statement (Appendix VIII, p.8) that "overwintering populations in the system downstream of the Cyprus Anvil Mine likely use Pelly River habitats and would not be affected".

This is a possibility, however, we are not aware of any information on fish habitats in the Rose Creek system to substantiate this statement. In fact, Beak states (p.3) that "it cannot be speculated without field data whether all classes of grayling in Rose Creek move downstream during fall, or whether juveniles overwinter in its smaller tributaries".

DFD suggested that such biological information should be collected, and CAMC retained Weagie Consultants to collect background data.

However, since insufficient time was available to conduct the required studies before the presentation of the Klohn Leonoff Report, we suggested to CAMC that any additional studies should await presentation and review of the Klohn Leonoff Report, and further discussions regarding the abandonment dam.

4. The chemical modelling, and impact assessment discussions do not consider metals other than zinc either in isolation or in combination. It is a well known fact that some metals, copper and zinc for example, act synergistically to increase the toxicities of either of these two substances.

In this regard, although we can accept the conclusion (p.2) that other heavy metals are not considered to be as significant as zinc, the fact that CAMC produces both lead and zinc, and that during the operating period of the mine effluent discharges have failed to meet licence requirements for lead and copper as well as zinc (Memo DFO to EPS, March, 1979) these and other metals should have been discussed in the water quality modelling.

5. Further to the above discussion, we note that Beak Consultants conclude (Appendix VIII, p.8) that to avoid synergistic effects of pollutants during the winter months "...the abandonment scheme should provide overwintering habitat other than over the tailings area".

It would appear that Klohn Leonoff either ignores this recommendation or argues that (a) synergistic effects would not be a problem (see item 4) or (b) zinc (and other metal) levels are not critical at this time of year. As noted in previous references to American Fisheries Society criteria (item 2) we consider that predicted zinc levels in the reservoir may be unable to sustain fish life during all seasons.

6. In addition to the above discussions, we note the following deficiencies in the report:

(i) ~~p.26 the report states that "most of the metals in the water occur as colloidal suspensions (probably colloidal hydroxides, since the dissolved metal concentrations (EPS, 1979) are substantially below the total metal level."~~

The EPS report cites only one occasion when a comparison of dissolved and extractable metals analyses were conducted. On this occasion dissolved zinc was 0.03 mg/l and extractable zinc was 0.105 mg/l at site 1, and non-filterable residue was 18.0 mg/l. This is insufficient data to make the stated conclusion.

- (ii) Appendix VII: Water Chemistry Model for Abandonment Plans makes references to several other instances where mine tailings are deposited into freshwater systems without apparent harm.

With reference to the Buttle Lake situation the author oversimplifies the problem of elevated zinc levels in the Lake. Contrary to the conclusion that "much of the zinc, however, results from natural geological processes in the drainage basin for the most recent studies (B.C. Research, 1980) showed elevated zinc levels in the tributary streams", it is more likely that increasing zinc levels are related to mine water drainages, chlor-alkali plant effluent tailings, slimes deposited in the lake as well as possible natural leaching.

As an additional example, the report cites as an example of lake disposal of tailings, West Twin Lake which is used as a tailing settling pond. The report notes that "since the operation started, zinc, iron, and lead levels in the water have increased to 0.2 mg/l (zinc), 0.15 mg/l (iron) and 0.1 mg/l (lead) respectively". This example appears to substantiate our concerns for problems associated with underwater disposal of tailings.

- (iii) The report states (p.22) that "both the laboratory experiments and field studies have projected the mobilization of zinc in the groundwater. This arises from either direct oxidation of zinc sulphide or indirect oxidation by redox reactions. ...the results demonstrate the necessity to minimize the seepage through the tailings. Although seepage is beneficial with regard to water quality in the water above the tailings, the concentration of zinc may become unacceptable if high seepage rates are mixed with surface water below the dam".

These statements seem to indicate that in order to satisfy all the requirements of an acceptable abandonment scheme, the structure must be designed to provide:

- minimum flows in Rose Creek downstream of the reservoir for fish production
- minimum pond depth over the tailings to prevent oxidation of tailings
- seepage control to prevent high zinc levels occurring downstream of the dam

We have serious reservations that all of the above critical design criteria can be met without additional field scale assessment.

- (iv) Appendix VII, Table VII - 8 (p.25) notes that at the lower groundwater seepage rate ($0.035 \text{ m}^3/\text{s}$), zinc levels in Rose Creek below the dam will range from a high of 0.12 to 0.12, May to December. However, at groundwater seepage rates of $0.12 \text{ m}^3/\text{s}$ zinc levels at this location will range from a high of 0.24 to 0.48 mg/l, January to April and a low of 0.05 to 0.07 from May to September and from 0.06 to 0.24 mg/l in October to December.

Thus the Klohn Leonoff Report states (p.40/41) that "seepage estimates indicate that with controlled placement of tailings seepage can be limited to a maximum of 0.2 m³/sec."

In view of the above predicted zinc concentration in relation to seepage rates of 0.035 m³/sec. and 0.12 m³/sec., the lower of which would appear to be required in order to achieve a maximum of 0.2 mg/l zinc downstream of the reservoir, it is unclear as to how a seepage rate of 0.2 m³/sec. will provide acceptable water quality.

- (v) Appendix VII p.13 suggests that even at pH > 7.0 where bacterial oxidation is slowed non-biological reactions can produce pH values of mean pH = 4.0 where bacterial oxidation take over further reducing the pH".

This statement in concert with Table VII - 1, and using the worst case situation (i.e. temperature 6°C, initial pH = 7.0, no bacteria present) indicate that dissolved constituents after 60 days were Cu 4.7 mg/l; pb 2.6 mg/l and zinc 422 mg/l.

These extremely high values for metals, particularly zinc, serve to further substantiate our concerns for adequacy of water chemistry modelling, and untried engineering systems in controlling contaminants from the abandoned tailings facilities.

- (vi) The flow-through section in the dam is preferable to a conventional spillway section incorporated into an earth filled dam. However, it also introduces uncertainty such as: discharge versus elevation relationships and the variation of this relationship with respect to time. This in turn, introduces uncertainty as to the depth of water in the reservoir at any given time.

The cross-section shown on drawing D-2758-117 seems to be adequate, coupled with construction procedures outlined in the report. The consultants should be requested to review the design of the non-flow through reaction of the dam with respect to the downstream slope. We suspect that the slope may have to be flattened towards the toe, instead of continuing as 3:1 all the way along.

Summary and Conclusions

Although the time available for review of the Klohn Leonoff Report precluded a detailed critique of many of the more technical and complicated aspect of both the water chemistry modelling and the hydrologic/engineering design of the various proposals, there appears to be a number of major concerns BFO has regarding the proposals. This includes:

- a) The adequacy of stated water quality criteria in protecting the fisheries resources in both the reservoir (of Scheme 2) and in Rose Creek.

- b) The lack of discussion on contaminants other than zinc in assessing environmental impacts.
- c) The adequacy of laboratory based water chemistry modelling in predicting actual water quality conditions following abandonment.
- d) The applicability of engineering studies and design structure in controlling seepage rate and thence guaranteeing adequate water quality.

The decision by the YVWB to allow construction of the Down Valley Tailings Disposal facilities and the need by Cyprus Avil to commence using their facilities by October, 1981, has severely restricted the options for alternate tailings disposals. However, the fact that the tailings abandonment scheme will not be required until cessation of mining operations allows time for more detailed study and re-evaluation of various options.

Recommendations

In light of the above, it is recommended that:

1. No final decision on the preferred abandonment option be given at this time.
2. Regardless of the abandonment scheme selected, continuing re-assessment of all abandonment options should be continued throughout the lifetime of the mining operation.
3. In conjunction with the theoretical water chemistry modelling, pilot studies should be conducted under actual field conditions in order to better assess environmental impacts.
4. As per earlier discussions with CAMC and their consultant, we recommend that fish distribution/habitat utilization studies be conducted in relation to the final preferred abandonment plan.

5. Re-examination of option 1 with supportive documentation provided.

The above studies and recommendations should be acted upon following development of adequate terms-of-reference between various government agencies including DOE, DFO, and DIAND.

References

American Fisheries Society 1979 A Review of the EPA Red Book: Quality Criteria for Water.