UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 26 1988

OFFICE OF
THE ADMINISTRATOR

The Honorable Lee M. Thomas
Administrator
U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, D.C. 20460

Dear Mr. Thomas:

The Mine Waste Risk Screen Subcommittee of the Science Advisory Board's Environmental Engineering Subcommittee has completed its review of the Office of Solid Waste's Draft Risk Screening Analysis of Mining Waste. The review was requested July 24, 1987 by the Deputy Director of the Office of Solid Waste and conducted at open meetings September 21-22, 1987 and October 22-23, 1987. It was approved by the Environmental Engineering Committee January 20, 1988 and now by the Executive Committee.

The Office of Solid Waste intended the model to be used for four purposes: helping EPA set priorities for collecting additional information necessary for developing the regulatory program, providing a context for performing analyses which lay out options for the scope of the regulatory program, helping to identify appropriate regulatory approaches for managing mining wastes, and serving as an initial step in complying with Executive Order 12291 which requires the Agency to perform Regulatory Impact Analyses for major regulations. The Subcommittee was to address four issues: the appropriateness of the risk screen given its intended uses and the quality of existing data, the need to consider additional pathway/receptor combintions which may lead to significant human exposure, the appropriateness of the tiered approach for determining when constituents should be deleted from further analysis, and the appropriateness of the assumptions used for developing air factors given the purpose of the analysis.

The Subcommittee finds that the general risk screen approach is appropriate and the risk screen methodology when implemented with all appropriate pathways and component models, can be used for setting priorities for collection of additional data. While the model may then be appropriate for a first step in preparation of Regulatory Impact Analyses, it should not in its current state be used to provide a context for performing analyses which lay out options for the scope of the regulatory program nor should it be used to help identify regulatory approaches for managing mining wastes. The Subcommittee identified additional pathway/receptor combinations which should be considered. The Subcommittee considers the tiered approach to be conceptually sound and the air emission factors appropriate for the present state of development of the risk screen analysis.

A risk-based screen can be an appropriate tool for setting priorites on the collection of additional data and on the promulgation of regulations. It should be recognized, however, that environmental risk assessment is in an early state of development and a quantitative model is neither the only available tool for assessing risk, given the Agency's intended purpose, nor necessarily the best tool given the quantity and quality of available data. For the pathways considered, the model is very conservative in some aspects, but it is not clear that the degree of conservatism is consistent between pathways. Many assumptions are made to simplify the computation and are justified on the basis that they are conservative and represent a "worst case" evaluation. The assumptions can result in of both the magnitude of risks as well as the frequency with which given risk levels are exceeded. The risk screen model needs to be validated and possibly modifed to demonstrate that the output corresponds with real conditions.

The Subcommittee appreciates the opportunity to conduct this scientific review. We request that the Agency formally respond to the scientific advice transmitted in the attached report.

Sincerely,

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Executive Committee
Science Advisory Board

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Environmental Engineering Committee
Science Advisory Board

Ben B. Ewing, Chairman
Mine Waste Risk Screen Subcommittee
Environmental Engineering Committee

cc: Donald Barnes
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SAB-EEC-88-028

REVIEW OF
THE OFFICE OF SOLID WASTE'S
DRAFT RISK SCREENING ANALYSIS OF MINING WASTES

REPORT OF THE

MINE WASTE RISK SCREEN SUBCOMMITTEE

OF THE

SCIENCE ADVISORY BOARD'S

ENVIRONMENTAL ENGINEERING COMMITTEE

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Date: November 23, 1987

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I. EXECUTIVE SUMMARY

This report presents the Science Advisory Board's review of the Office of Solid Waste's (OSW) "Draft Risk Screening Analysis of Mining Wastes." The analysis applies to extraction and beneficiation wastes but not to processing wastes. The screening is proposed by OSW to be used to establish priorities for additional data collection for regulatory development, as a first step in preparation of a Regulatory Impact Assessment (RIA), to help lay out options for a regulatory program, and to help identify regulatory approaches. OSW posed four questions upon which it seeks SAB advice.

After briefing and more detailed review of the draft report and appendices, the Subcommittee concluded that the overall modeling methodology is sound, but there is concern for the validity of some pathway transport models. In addition, the models utilize sparse and uncertain input data. For these and other reasons discussed below, the output results can not be taken to represent reality, although some of the results look reasonable. Therefore the use of the screening analysis is only appropriate for setting priorities for collection of additional data and possibly for a first step in preparation of the RIA. It is not yet appropriate to set relative risk. EPA is also cautioned not to use the screen analysis for purposes for which it was not intended.

The structure of the analysis does not consider many of the important physical and chemical interactions between the contaminant constituents and the environment which are known to play a role in the transport from the source to the receptor. The ground water model is simplistic, though appropriate for the data available, but the estimated soil erosion and runoff to surface water are uncertain. The atmospheric transport route appears to result in unreasonably low deposition rates.

The analysis suffers from a paucity of input data, particularly for source emission terms. The use of the EP toxicity test for setting concentrations of leachates in one mining segment is questionable. The importance of selection of 1/2 the detection limit in cases where the measured concentrations in leachate are below the detection limit should be examined. Alternatives are available.

A number of other pathway/receptor combinations should be considered and included if they can not be shown qualitatively to pose insignificant risk. In particular, it is recommended that consideration be given to the impact on the terrestrial food chain, and on benthic aquatic organisms. The possible direct runoff of liquid wastes to surface streams should be considered.

The report should provide a more explicit list of assumptions upon which it is based. The assumption has been made that there are no engineering or management controls in effect at the mine sites, and that there is no treatment of surface water prior to drinking. It is assumed that there is no adsorption of metals on stream sediments. These and several other questionable assumptions make some of the results unrealistic, in many (but not all) cases.

The analysis has omitted some important considerations as well. The environmental effect of acid mine drainage and its effect on metal migration has not been included in the analysis. Eutrophication of surface waters in the vicinity of phosphate mines is known to be a problem and yet the analysis does not address this issue. Neither are the adverse health risks associated with asbestos, cyanides and methyl mercury incorporated in the analysis. Finally, it does not consider the possibility of spills such as tailings pond dike leaks.

The reliability of some of the reported results of the analysis appears doubtful in view of our experience. The identification of constituents which contribute most to the high risk are often not the ones expected; silver turns out to be more important in contributing to human health risk and environmental impacts than copper and cadmium even for the copper and lead/zinc mining segments, according to the analysis. Some of the source leachate metal concentrations do not look reasonable. The surface runoff path is known to be an important route for environmental contamination but no mining segments in this model showed surface water concentrations in excess of the reference dose (RFD) for aquatic organisms. The atmospheric deposition rates used to determine the off-site direct contact health risk are unbelievably low.

The Subcommittee's responses to the four questions posed by OSW follows:

1. Is the risk screen an appropriate tool given its intended uses and the quality of existing data?

   The general risk screen approach is appropriate and the current risk screen methodology, when implemented with all appropriate pathways and component models, can be used for setting priorities for collecting of additional data. It may be appropriate for a first step in preparation of the RIA. The risk screen model in its current state should not be used to provide a context for performing analyses which lay out options for the scope of the regulatory program nor should it be used to help identify regulatory approaches for managing mining wastes. The risk screen model could become an acceptable tool for all four of the intended uses if appropriately calibrated and field validated. The model needs to be validated to demonstrate that the output corresponds with real conditions. Some of these modifications are underway.

2. Are there additional pathway/receptor combinations which should be considered?

   At least seven additional pathway/receptor combinations should be considered (See Section VI for details).

3. Is our use of a tiered approach appropriate to determine when constitutuents should be deleted from further analysis?

   The tiered approach is conceptually sound and could be further developed in future refinements of the risk screen analysis models.

4. Are the assumptions we used for developing air factors appropriate given the purpose of the analysis?

   Assumptions on which the air emission factors are based seem to be appropriate for the present state of development of the risk screen analysis.

Specific recommendations for validaion and refinement of the models are provided (See Section IX).

It is recognized that OSW asked the SAB to review the draft Risk Screen Analysis of Mining Waste at an early stage. The OSW is responsive to the SAB's comments in its on-going process.

II. INTRODUCTION

On July 24, 1987, Jeffery D. Denit, Deputy Director of the Office of Solid Waste requested that the Environmental Engineering Committee (EEC) of the Science Advisory Board review the Draft Risk Screening Analysis of Mining Wastes.[1] The analysis applies to extraction and beneficiation wastes but not to processing wastes. Mr. Denit described the four purposes for which the risk screening analysis was intended to be used as follows:

(a) Help EPA set priorities for collecting additional information necessary for developing the regulatory program;
(b) Provide a context for performing analyses which lay out options for the scope of the regulatory program;
(c) Help identify appropriate regulatory approaches for managing mining wastes; and
(d) Serve as an initial step in complying with Executive Order 12291 which requires the Agency to perform Regulatory Impact Analyses for major regulations

Mr. Denit also posed four questions which he requested the EEC to consider and provide advice. These questions are as follows:

(1) Is the risk screen an appropriate tool given its intended uses and the quality of existing data?
(2) Are there pathway/receptor combinations which we have not considered that may lead to significant human health exposure?
(3) Is our use of a tiered approach appropriate to determine when constituents should be deleted from further analysis?
(4) Are the assumptions we used for developing air emission factors appropriate given the purpose of the analysis?

On that day, staff of the Office of Solid Waste and contractor personnel briefed the Environmental Engineering Committee on the draft document and the procedures used in structuring the risk screening analysis.

The EEC formed a Subcommittee to review the draft in more detail and prepare a draft report. The membership of the Subcommittee and the rest of the EEC appears at the front of this report. The Subcommittee met on Sept. 21 & 22, 1987 and was further briefed by Mr. Cliff Rothenstein and others of the Office of Solid Wastes together with staff of the contractor, ICF Incorporated. The Subcommittee also heard presentations by representatives of the American Mining Congress and the Kennecott Corporation.

The Subcommittee's findings were discussed and accepted by the EEC and subsequently reviewed and approved by the SAB Executive Committee.

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1 "Draft Risk Screening Analysis of Mining Wastes", prepared by ICF Incorporated for the Office of Solid Waste, U.S. Environmental Protection Agency, July 23, 1987.

III. GENERAL COMMENTS

This report focuses solely on the scientific quality of the mine waste risk screening analysis, relative to the current state-of-the-art of risk analysis. The review is not and should not be construed as an endorsement or rejection of the use of risk screening analysis in regulatory decision-making.

A risk-based screen can be an appropriate tool for setting priorities for the collection of additional data and on the promulgation of regulations. It should be recognized, however, that environmental risk assessment is in an early state of development, and a quantitative risk assessment model is neither the only available tool for assessing risk, given the Agency's intended purpose, nor necessarily the best tool given the quantity and quality of available data. Environmental risk is a function of the hazardous materials involved, pathways of migration, target organisms, and engineering and management control practices. These factors can be evaluated qualitatively (e.g., via best engineering judgement), semiquantitatively (e.g., via a scoring system similar to the CERCLA Hazard Ranking System (HRS) or the nine-box RAG matrix for displaying risks by frequency and severity), or quantitatively (e.g., via mathematical models). Quantitative assessment is, prima facie more sophisticated and intellectually satisfying than qualitative or semi-quantitative approaches. However, the state-of-the-art and the available data do not always justify its use. Even if quantitative assessment were possible, it would be useful to evaluate the results qualitatively to assure that they are physically reasonable, or that they can be explained logically.

For the pathways considered,the model is very conservative in some aspects, but it is not clear that the degree of conservatism is consistent between pathways. Many assumptions are made to simplify the computations and are justified on the basis that they are conservative and represent a "worst-case" evaluation. While the objective is to insure that no segment/pathway case is eliminated unless it is clearly on the safe side and the risk is indeed insignificant, the assumptions can result in inconsistent estimates of both the magnitude of risks as well as the frequency with which given risk levels are exceeded. Particular cases where the committee questions the degree of conservatism used are presented in the following sections.

The risk assessment is made for the most exposed individual (MEI). Presumably the MEI is that hypothetical person whose residence and living Patterns make for the greatest exposure. This approach is conveniently conservative, but in fact the MEI may not exist. The estimation of probability of exposure to the population is a sounder approach. Use of a combination of the MEI and the population risk probability approach might be used in a tiered computation, where the MEI is used for early tiers and then a more refined (and more real) population approach used for the more precise computation in later tiers.

One additional General Comment is that the title should include the term, "beneficiation" because the report covers risks from mining extraction and beneficiation, but not smelting and refining wastes.

IV. STRUCTURE OF MODEL

Use of the Industrial Source Complex Long-Term (ISCLT) model is appropriate and may be the best available model at this time. If used properly, the ISCLT model is likely to yield a good estimate of the air emissions from mining waste-related activities. The question is the validity of the emission factors as developed in Appendix F and the descriptions used in Chapter 4.

The model assesses the effect of physical processes on the transport of hazardous substances from the mine waste unit to the MEI, but the only chemical interaction which is considered is the adsorption/desorption represented by the partition coefficient, Kd. It is inconsistent that adsorption is considered in the ground water transport, but not in surface water. The assumption that all of each metal constituent is immediately dissolved in a surface stream is unreal. The most serious omission is the failure to consider any other soil-waste interactions such as precipitation or oxidation-reduction reactions. It is observed (page 4.4) that "Because the contaminants modeled in this study are inorganic and therefore do not degrade, travel through the unsaturated zone has no effect on contaminant concentrations." While it is true that inorganic species do not degrade, they do undergo other physico-chemical phenomena which can cause significant changes in chemical concentration and specification both in the unsaturated zone and in the saturated ground water transport system. If data, such as pH and redox conditions, are not available to permit consideration of these chemical phenomena, that fact should be commented on in the report. To the extent that these data would drive risk in a more realistic model this is an obvious gap in the existing data and would have high priority for future data gathering.

The groundwater transport model used is not the most sophisticated available, but is an appropriate choice, given the quality and quantity of available input data. Nonetheless, the model used does not take into account many physical and chemical phenomena that have an important influence on the transport and fate of inorganic contaminants in the subsurface environment. The physical phenomena include the heterogeneity and anisotropic behavior of soil permeability and porosity. If site specific data were obtained for these properties, more sophisticated numerical modeling procedures would be appropriate. The chemical phenomena include changes in tha equilibrium concentration as a function of pH and redox potential. The partition coefficients used in the model should be included in the report, along with a discussion of the bases for their selection. Consideration should be given to determining the sensitivity of the model predictions to variations in the partition coefficient. The possibility that competitive adsorption could reduce the adsorption of some metals could be considered. Variation in the assumed partition coefficient could also be used to consider the effect of pH and redox conditions on ground water transport.

The transport of metals from mine waste units to surface streams by soil erosion and sediment transport mechanisms is modeled by the Universal Soil Loss Equation (USLE), and the assumptions are made that all particles removed from the waste management unit by erosion are transported to the receiving stream, and that there is no liquid waste runoff to surface streams. These assumptions have not been validated. The USLE was developed to predict soil erosion from agricultural land and has not to our knowledge been used for mining wastes other than coal mine overburden. It is not clear that the equation can be used for metal mine wastes such as tailings, waste rock, low-grade ore and sludges where there is a wide range of particle sizes, density, and management practices. Also, mine sludges, fresh tailings, and tailings pond settled solids are usually placed in impoundments where runoff from exposed wastes would flow into a Pond and many solids would settle out of solution. While it is not clear that other modeling approaches are available for use in lieu of the USLE. The questionable result of its use is planned to be recognized explicitly in a future draft.

Because site-specific data for a full analysis of risks for various segment/pathway/receptor combinations are lacking, estimates of various parameters at each mine are made using a Monte Carlo approach. The distributions of parameters are input to the transport exposure models to estimate the distribution of effects. The principal uncertain parameters are the waste site dimensions, site geologic properties for runoff and groundwater transport, and leachate and solids source concentrations.

The Monte Carlo approach is sound and reasonable. Furthermore, it is supported by an analysis of model sensitivity in Chapter 7 of the report. There are, however, some difficulties with particular aspects of the methodology and the way in which it is presented in the current report.

The intent of the Monte Carlo analysis is to charaterize the variablility of risks likely to occur across a mining segment. To accomplish this, actual individual mine sites are used with the Monte Carlo Calculations used to determine the range of parameters at each location. However, it is not clear exactly what the computed risk distributions represent in chapter 5 of the report, in Exhibit 5.1, 5.2, etc. The results are given as the percent of "runs" exceeding a given risk level. How are these "runs" (i.e., Monte Carlo replications of the transport-exposure model) allocated among the individual mines in each segment? Presumably on an equal basis, but this is not clear from the report. It is thus not apparent whether the computed risk distribution applies at each site, or only to the aggregation of sites across a segment. A clearer statement of the role and interpretation of the Monte Carlo analysis should be provided in the report.

Furthermore, the probabilistic interpretation of the Monte Carlo results, i.e., that a given percent of the "runs" or cases result in a given risk level, is also questionable. These percent exceedances are a direct result of the shape of the input distribution functions used for the uncertain parameters. These distributions were in most cases assumed to be uniform, because of the lack of information on the actual shapes of the distributions. Thus, the basis for the percent exceedance estimates is itself very uncertain. A clearer discussion of the meaning of the Monte Carlo results must be provided in the report to address this issue and to clarify the intended interpretation.

A number of questions arose concerning the methodology, for simulating distributions of leachate concentrations at the mine sites. To determine these distributions sample results from mines in each segment were grouped, the range of sample results were assumed to represent the range of possible concentrations. The number of samples ranged from 3 to 44 per segment (Exhibit 3.1). The individual samples for a segment were assigned equal probabilities in the Monte Carlo procedure.

This again represents a good overall approach to a difficult engineering problem. In particular, it provides a range of leachate con centration values for each constituent, while maintaining the inherent correlation which occurs between constituents in real samples. Unfortunately. We are unable to judge how representative these samples are of the range of possible leachate concentrations without seeing the sample results. Do three samples provide an adequate representation, or are many more needed? Do the differences between mine segments appear to be reasonable? Are there any anomalous concentrations which could bias the analysis? The authors should discuss the range of leachate concentrations presented in Appendix H of the report it allows us to better evaluation of their respresentatives. Appendix H entitled "Distribution of Waste Constituent concentrations" provides the range of leachate concentrations" provides the range of leachate concentrations used in the risk screen. Much of the source data for metal concentrations is reported to be below the detection limit for the analysis. In these cases, the practice followed was to assume the actual value is one-half (1/2) the detection limit. Since it would not be correct to assume all these values are at the detection limit, nor would it be correct to assume they are zero, the compromise value of 1/2 the detection limit was chosen. Using 1/2 the detection an limit been previously applied as an assumption. In view of the typical log-normal distribution of concentrations frequently found in environmental samples, the 1/2 detection limit value may be conservative; on the other hand, that is not known to be the case. Other methods for extrapolating values above the detection limit to estimate values below the detection limit have been reported [2,3].

2 Gilliom, R.J. and D.R. Helsel, "Estimation of distributional parameters for censored trace level water quality data I. Estimation techniques,"

3 Helsel, D.R. and R.J. Gilliom, Estimation of distributional paramenters for censored trace level water quality data, II. Verification and Applications, "Water Resources Research, 22, 2. pp. 147-155 (Feb. 1986).

These alternative methods should be discussed in the report and the reasons for selecting the 1/2 detection limit approved. Neither of these methods are applicable in this case or in any case where more than one detection limit exists i.e., where more than one analytical instrument is used to determine concentrations.

There may be a need to rerun the model using data at the detection limit to see if the risk is significant at that source level. If it is, one should place a high priority on gathering source concentrations with an analytical method designed for a lower detection limit. In no case should a parameter below the detection limit be the prime risk determining factor.

V. SOURCE TERMS

In an analysis of this type, it is crucial that the source terms be correct. There is a reported paucity of data on the many factors included in the estimate of the emission sources. According to the report and appendices, no data were available regarding several constituents in some mining segments. Unfortunately, as the report stands, "no data" could effectively end up being interpreted as "no risk," although that is not the intention.

On the other hand, fairly complete data were available concerning the open pit copper mining segment. Only 14% of the mines had data on water extracts. The most complete record was in the area of waste quantity generated, in which 40% of the mines had data. Following is a breakdown by area of the completeness of the record:

1. Raw liquid constituents	26%
2. Water extract constituents	14%
3. EP extract constituents	24%
4. Solid sample constituents	27%
5. Quantity of ore mined	39%
6. Quantity of waste generated	40%
7. Disposal site characteristics	31%

Further discussion of the completeness of the data base should be presented in the report. Data from all the different sources should be examined to determine the degree to which they are internally consistent.

The air emission factors used will be discussed below in response to the last of the four questions posed by OSW for the SAB review.

It is noted that, where available, constituent concentrations for standing water were used in preference to the EP toxicity test, which is good. The acid extraction results may overestimate the release of metals under near neutral conditions and where acid generations does not occur. In these situations, a mildly acidic solute' similar to rainfall is probably preferred to the acetic acid used in the EP test. Column experiment results would provide the best estimate of leachate quality when acid generation is not expected.

Interstitial water in talings may be higher in concentration than standing water or the EP toxicity test. If the EP test is to be used, it should be validated to show it is yielding reasonable concentrations for the leachate, or a revised leaching procedure more appropriate to mining wastes should be developed and used to estimate the leachable portions of mining wastes.

It is questionable whether liquid data for tailings pond supernatants, mine wastes, pond liquids, plant waste waters and spent leach liquors should be pooled together. Contaminant levels are expected to vary significantly between the waste categories and within waste categories. For example, acid wastes are likely to have high concentrations of contaminants, while alkaline streams contain low levels. Pooling results may distort the frequency of calculated risk exceedances.

Waste management units are lumped together as impoundments. Waste rock dumps, leach liquor ponds, and sludge ponds behave very differently in both the geohydrologic and geochemical sense.

Simple analysis of fluids or acid extracts would likely miss potential contaminant release from mining wastes which have the potential for, but are not yet, generating acid mine drainage. In this way, the model may underestimate the risk of some sites.

The source term data base should be strengthened substantially. Assistance from the mining industry should be enlisted to reduce the cost of data collection. Data already reported to state regulatory agencies in NPDES permits, air permits and ground water quality data should also be sought.

VI. PATHWAYS

The risk screen methodology considers several pathways of exposure including (1)leachate/ground water/well/ ingestion of drinking water, (2)rainfall/arosion/runoff/surface water/ingestion of drinking water, (3)leachate/ground water/surface water/ingestion of drinking water, (4)runoff/surface water/aquatic biota, (5)leachate/ground water/surface water/aquatic biota, (6)inhalation of air-borne particulates, (7)off-site direct contact via air-borne particulates/deposition/gardening/ingestion of soil, and (8)on-site direct contact via ingestion of particulates while engaged in dirt bike riding on the mine site. These may very well be the pathways of exposure which create the greatest risk, but there are some other pathways which should be considered and, if found to be insignificant, the rationale for their exclusion should be incorporated in the report. These additional pathways include:

1. Surface water/sediment/benthic organisms or bottom feeding organisms.

2. Runoff/surface water/irrigation/soil concentration/food chain/ingestion.

3. Direct runoff of soluble waste from mine sites (mine water, tailings pond supernatant and seepage, and waste rock pile runoff and seepage, for example, to surface waters.

4. Atmospheric deposition/surface water/ingestion of drinking water.

5. Either runoff or air deposition to soil/ingestion by terrestrial biota/ biomagnification in the human food chain.

6. On-site direct contact of biota, such as animals grazing on plants growing on mining wastes or drinking fluids on-site. or waterfowl using impoundments.

7. Surface water/ground water/well/ingestion of drinking water might be a route by which the contaminants could migrate more rapidly and for further distances to contaminate distant wells than in the case of the leachate/ground water/well pathway. It is true, however, that in the case of the surface water/ingestion pathway the MEI is exposed to higher concentration than would be the case with subsequent percolation in ground water to a well.

It is recommended that these and possibly other pathways be considered and discussion of the reasons for their not being included in the analysis offered in the text.

VII. ASSUMPTIONS

As noted above, the analysis is based on numerous assumptions, many of which are intended to produce a very conservative estimate of risk, a worst case estimate. Explicit identification of the assumptions in the report is recommended; these might follow the example of the assumptions used in the ground water model presented in Appendix D. Some of the assumptions noted in this review are discussed below. They are not in any particular order.

The report does state the assumption that thare are no engineering or management controls on any of the waste management units, except for the wetting of haul roads. The effect of this assumption would be a higher frequency of risk exceedance than actually exists in the mining industry. Where state regulations are enforced and/or where controls are standard practice, such controls should be assumed. This refinement may result from the planned development of a state regulation "overlay".

Only reversible adsorption is considered in the ground water transport model and other soil interactions are neglected. This has been discussed above.

Off-site direct contact is based on the assumption that the atmospheric deposition is mixed in the soil to a depth of one centimeter. This may be a valid assumption for untilled soil such as lawns, but it seems more likely that the mixing depth in gardens is more like ten centimeters. Gardening is the assumed activity of exposure of the MEI.

There is no allowance for treatment of drinking water taken from surface water sources. It would seem that few surface waters in mining areas could meet drinking water standards without treatment, particularly in those reaches downstream from the mine waste discharge. Further rural water supplies taken from surface sources are increasingly apt to be treated, at least by filtration. One reason that treatment has not been assumed is that the assumption was made that all the metal contaminants which reach the stream are dissolved. While clarification by filtration would not remove a large amount of dissolved metals, ion exchange softening would.

On the other hand, assuming that the metals in the stream are all dissolved raises another issue. No allowance is made for the possibility that much of the metals are adsorbed on suspended sediments and are removed from the overlying water column to the bottom sediments. This would reduce the risk to humans drinking water from the stream and the risk to plankton, but it might increase risk to benthic organisms and bottom feeding fish.

Related to this is the assumption that all the metal constituents are completely bioavailable.

All mining sites are assumed to include beneficiation and are assumed to produce tailings. Many small mines are involved only with the extraction of ore. Modeling these mines as if they are producing tailings overestimates their probable contaminant source and hence overestimates the risk. If the risk screen model has a size cutoff which excludes these small mines, the assumption would be valid. The assumption that the entire disturbed area of a mine site, as indicated by topographic maps, is an active waste management unit is conservative also.

The MEI is assumed to reside at the waste management unit boundary. In most cases, this would be on-site, assuming the mine property extends beyond tha boundary of ths waste management unit. It appears that the assumption regarding place of residence of the MEI is therefore conservative.

It is assumed that all the rain falls on the waste management unit, such as waste piles, and all the runoff reaches the nearby surface stream. No allowance is made for storm water dilution by rainfall on adjacent parts of the drainage basin.

Evaluation of the aquatic impacts required input data regarding the proximity of wetlands and lakes in proximity to the site. In cases where the mine site was near the border or a corner of a USGS quadrangle map, the assumption was made that conditions in the other side of the border or the other quadrants of a corner were similar to those on the USGS quadrangle for the mine site. It is not clear why adjacent quadrangle maps were not obtained and consulted.

VIII. OMISSIONS

There are also a number of considerations which are omitted from the analysis, sometimes without comment. These will also be noted.

(1) No account is taken for the adverse environmental effects of acid mine drainage on biota. It is recognized that the production of acid in waste rock piles and in mine waters is dependent on the availability of oxygen to oxidize sulfur, and the availability of oxygen is very difficult to model. Perhaps the emission of acids can be determined from analysis of leachate or runoff from actual sites. Incidentally, the pH will also affect the transport of metals.

(2) Aluminum is not included in the leachate parameters. It is an important contaminant causing environmental damage at several acid generating mine sites.

(3) The effect of phosphate runoff from phosphorus mine sites on the eutrophication of receiving streams has not been considered. This is known to be a problem in phosphate mine areas.

(4) Cyanide toxic effects on both terrestrial and aquatic biota are not considered. If this is due to the lack of data, that should be acknowledged in the report.

(5) The methylation of mercury in anaerobic sediments and the bioavailability and toxicity of organic mercury are not discussed.

(6) The effect of asbestiform particles has not been considered.

(7) No effort has been made to account for spills, such as leakage of a tailings pond berm and release of large amounts of tailings to a surface stream.

IX. RELIABILITY OF RESULTS

The need to look at results of the model to determine whether they seem reasonable in view of best engineering judgement has been pointed out above. It would be easier to compare results with engineering experience if the results were presented as concentrations in air and water rather than in terms of health risks. Some examples of results which do not appear to conform to our expectations are cited.

The failure of copper or cadmium (which is associated with zinc) significantly to the risk, even for the copper mining or lead/zinc mining segments and even for ecologic impact in aquatic biota, does not appear to be reasonable.

The fact that silver does dominate the risk, even in the copper mining segment also seems strange. The usual experience is that silver rarely is released from mining wastes and detected in the environment. A possible explanation for the high relative risk for silver is that the AWQC for silver is extremely low, even below the detection limit. Another possibility is the low partition coefficient, Kd. This should be explored further. If silver were a concern, it would be likely in the gold/silver and lead mining segments where it is known to occur. Copper tailings liquors contain very high levels of contaminants and it is possible that silver may be present. However copper concentrations would be orders of magnitude higher than silver and represent a greater threat to the environment.

Table I, taken from Appendix H of the Risk Screen report, summarizes the mean concentration of metals in leachate by segments. There are several results indicated in this table which should be checked. Of note are the relatively low levels of silver in all segments supporting the view expressed above that silver is not likely a significant contaminant in the groundwater pathway. Also radium and uranium data is sparse for all segments, suggesting any conclusions regarding these contaminants are tentative.

Some of the highest concentrations of contaminants were found in the copper leach segment (particulary for copper lead, zinc and arsenic). Elevated levels of copper and zinc, though not to the same level, were found in the copper segment. Yet, in spite of these higher concentrations in the leachate, relatively few of the runs resulted in excess of the AWQC, due to long time of travel. This may be related to the assumed partition coefficient and/or the location of these facilities in the arid west, but the result should be checked.

It is reported that arsenic, uranium and radium were the only components causing human cancer risk through ingestion. Two of these contaminants are radioactive and yet the uranium/vanadium pit segment had only 3% and 6% that exceeded one-per-million cancer risk for the ground water/well and ground water/surface water pathways, respectively. Arsenic has shown up as a key constituent based on the current CAG potency factor for a cancer risk threshold of 10^{-6}. Yet, this threshold is under review by the Agency. Arsenic is also an essential trace element, and the drinking water standard of 50 micrograms per liter corresponds to a lifetime individual cancer risk of 10^{-2} to 10^{-3}.

Generally, segments in the runoff/surface water pathway did not exceed the reference dose (RfD) for the non-cancer human health risk. Yet experience suggests that in some places the surface water pathway is an

Table 1. Mean Concentration of Contaminants in Leachate by Segment (Extracted from Appendix H of the Draft Risk Screening Analysis of Mining Wastes)

concentration in mg/1

Segment*	Ag	Cu	Hg	Pb	Zn	As	Ra	V
Antimony	0.033 (7)	0.31 (7)	0.0031 (7)	6.6 (7)	5.6 (7)	37 (7)	(0)	(0)
Asbestos	0.005 (8)	0.057 (8)	0.0005 (8)	0.025 (8)	0.05 (8)	0.014 (1)	28 (1)	(0)
Bauxite	0.0024 (10)	0.047 (10)	0.00018 (12)	0.037 (12)	1.0 (12)	0.038 (2)	(0)	(0)
Belea	0.005 (3)	0.0073 (3)	0.0005 (3)	0.13 (3)	3.5 (3)	1.5 (2)	479 (3)	(0)
Copper Leach	0.016 (7)	940 (7)	0.00041 (7)	1.5 (7)	142 (7)	3.4 (7)	(0)	(0)
Copper Seg.	0.03 (18)	49.5 (18)	0.00042 (18)	0.10 (18)	20.6 (18)	0.14 (15)	6.2 (2)	310 (2)
Gold/Silver	0.074 (14)	6.1 (14)	0.081 (2)	0.063 (2)	9.1 (12)	0.36 (12)	(0)	(0)
Iron	0.0045 (7)	0.012 (7)	0.00026 (7)	0.041 (7)	5.6 (7)	0.035 (4)	1.2 (2)	1.95 (2)
Lead/Zinc	0.0083 (21)	0.032 (21)	0.0029 (21)	0.068 (21)	0.11 (21)	0.017 (13)	1.2 (3)	1.5 (3)
Mercury	0.029 (4)	0.56 (4)	75 (4)	0.95 (4)	3.8 (4)	12.0 (4)	(0)	(0)
Molybdenum	0.021 (11)	0.036 (11)	0.0038 (11)	0.094 (11)	0.19 (10)	0.064 (11)	33 (2)	1596 (3)
Nichle	0.0030 (8)	0.019 (8)	0.00028 (8)	0.0196 (8)	0.073 (8)	0.041 (8)	(0)	(0)
Phosphate	0.0055 (12)	0.042 (12)	0.0012 (11)	0.090 (12)	0.38 (12)	0.032 (8)	7.3 (12)	29 (12)
Titanium	0.08 (4)	0.68 (4)	0.001 (4)	1.6 (4)	1.2 (4)	(0)	56 (2)	(0)
Tungsten	0.005 (3)	2.3 (3)	0.0003 (3)	0.025 (3)	0.14 (3)	0.02 (1)	(0)	(0)
Uranium/ Vanadium	0.028 (44)	0.73 (44)	0.020 (44)	1.5 (44)	20 (44)	0.16 (32)	40 (12)	420 (7)

*mean (number of values)

values that should be checked

important route by which contaminants significant to both human health and aquatic life enter the environment from mining sites.

The atmospheric deposition rates calculated by the model are infinitesimal. Perhaps this is why the cancer risk for direct off-site contact is very small. Exhibit 5-12 indicates that the deposition rate is equivalent to approximately 0.1 mm per year. This may be due to the fact that only those particles smaller than 30 micrometers in size are assumed in the atmospheric transport from the source to the boundary. Perhaps the major deposition is really due to larger particles. Apparently the result does not stem from movement of the plume aloft over the receptor because of the "stack height" effect, because the deposition ratas apparently do not increase with further distance from the source. If the curve-of-best-fit in Exhibit 5-12 does not go through the origin, comment should be made about the physical significance of the intercept.

X. RESPONSE TO THE QUESTIONS POSED

Four questions were posed to the EEC by the Office of Solid Waste and these were listed in the Introduction of this report. Responses to the questions will be provided in the order presented.

Is the risk screen an appropriate tool given its intended uses and the quality of existing data?

The risk screen approach is appropriate for use in establishing Priorities for collecting additional information. There is a paucity of information and extensive further data gathering will be necessary to fill gaps before regulations can be developed. Large holes have already been identified in the data base. Some of the data collection will be costly, so priorities are important. The risk screen methodology, when implemented with all appropriate pathways and component models, can provide insights into which of those data gaps must be filled bsfore the Agency can start to develop regulations. However, the model output results do not yet provide these insights.

There is concern regarding its use as a first step in the preparation of a Regulatory Impact Assessment (RIA) in compliance with Executive Order 12291. It depends on the nature and purpose of the "first step". The RIA assesses the economic impact of new major regulations, and typically weighs the costs of implementation against the environmental and human health benefits derived. In principle the risk screening model could be used to evaluate the benefits of regulations in terms of risk reduction. In practice, the risk screen incorporates many questionable assumptions. It should not be used beyond a first preliminary step in the RIA, therefore, because there is no assurance that the risks it projects are real.

The risk screen model in its current state should not be used to provide a context for performing analyses which lay out options for the scope of the regulatory program, nor should it be used to help identify regulatory approaches for managing mining wastes. If the model were fixed and provided with some additional degree of validation and additional source data were developed, then it could be an appropriate tool.

Are there pathway/receptor combinations which we have not considered that may lead to significant human health exposure?

It is assumed that the question also applies to environmental effects as well as human health. Additional pathways of exposure have been listed in Section VI. Many, or perhaps all, of these suggested additional pathways may be of lesser significance than the eight pathway/receptor combinations incorporated in the analysis, but there is need for at least a qualitative evaluation of them and discussion of the reasons they are not included.

Is our use of a tiered approach appropriate to determine when constituents should be deleted from further analysis?

The concept of a tiered approach is sound. The use of conservative assumptions in the early tiers is appropriate. However there is a need to demonstrate that the assumptions are consistent with the range of field conditions and yield results which are in a realistic range.

Are the assumptions we used for developing air emission factors appropriate given the purpose of the analysis?

The data base for air emissions is obviously very scarce. It is difficult to determine the quality of the emission data because of the high degree of uncertainty in the model. It would be easier to judge whether the emission factors are reasonable if atmospheric concentrations could be compared with field experience.

The air emission factors appear to be of the right order of magnitude, but are conservative when compared to values used in other efforts to model disposal of flyash. For example, the emission values used in Appendix F for haul roads with 50 percent control efficiency for western mines was 8.2 lb/VMT. A similar calculation for haul roads for fly ash disposal was calculated to be 4.5 lb/VMT. Fly ash dust might be expected to have higher emissions than tailings. This is another example of a conservative assumption.

The equation used for the emission factor for dumping dry material in waste piles used in the Appendix F was E =0.027 x(windspeed, mph) lb/ton for taconite. A similar calculation for flyash yields 0.014 lb/ton of flyash assuming a 5 mph windspeed. The value used in the risk screen model again appears to be of the right order of magnitude.

4 Personal communication, Mr. George C. Green, Public Service Company of Colorado, October 7, 1987.

The question is not whether the air emission factors are correct, but whether the assumptions made in developing air emission factors are correct. The assumption that the most important sources of fugitive dust at typical mine sites were mine waste piles, dried tailings piles, and haul roads seems reasonable and apparently the preliminary analysis of the data supports this assumption. It must be recognized however that each of these sources is highly variable for different sites and temporally variable at any given site.

Recent reviews developed by Sehmel [5], and Smith, et al. [6] on saltation suspension and resuspension models, could provide additional insight into the relative magnitude of particle emissions from mining wastes through road travel or wind erosion, relative to other particulate emission sources, and can provide a check on the estimates obtained from the AP-42 manual.

Also, in regard to fugitive dust emission factors for the initial screen, reductions of 50 percent are taken for haul roads to reflect watering or chemical stabilization and of 50 percent for tailings to reflect wetting following precipitation. Our experience indicates that a more reasonable control level would be 85 to 90 percent for chemical stabilization versus the 50 percent assumed in Appendix F. However we agree that 50 percent is an adequate assumption. In the next step of EPA study when controls that are required by States or practiced widely are formally imposed upon potential emissions, discussion of controls should be expanded. Also, discussion of control techniques for waste piles is needed. Useful information sources include references 3 to 30 in Appendix B; these are selected from Turner, et al. [7].

XI. RECOMMENDATIONS FOR FUTURE WORK

The risk screen model should be appropriately validated. A first step is to compare the concentration of constituents in air and water with "best engineering judgement." An expert, or panel of experts, familiar with mining impacts could make this comparison. In the next step, the concentration of constituents in water taken from existing wells at some specific sites could be compared with model output data for the site conditions. Similarly, airborne concentrations measured at specific sites could be compared with model predictions. This should be done for a variety of sources, pathways and receptors for mine sites spanning the range of commodity segments.

[5] Sehmel, G.A. 1980. Particle Resuspension: a Review. Environmental Inter., 4:107 127.

[6] Smith, W.J., F.W. Whiacker, and H.R. Meyer. 1982. Review and Categorization of Saltation, Suspension, and Resuspension Models. Nuclear Safety Journal, 23(6):685.699..

[7] Turner, J.H., et al.. Fugitive Emissions from Hazardous Waste Sites, RTI, Revised Draft Report, EPA Contract 68-03-3149, 1984.

The model should be applied to source term and environment conditions applicable to situations where known problems have been observed, including: acid mine drainage, mobility of metals in water and air, asbestos and radioactivity. Since these technical issues are know to generate real problems at mines sites, the models should be capable of predicting risk for these inputs.

It might be well to look at some of the theoretically questionable estimates, identify the errors in the model which lead to the questionable results, revise the model, and re-examine the output.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 24 1987

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Science Advisory Board Review of the Mining Waste Risk Screen Report

FROM: Jeffery D. Denit, Deputy Director, Office of Solid Waste (WH-562)

TO: Dr. Terry F. Yosie, Director, Science Advisory Board (A-101)

Attached is OSW's report entitled "Draft Risk Screening Analysis of Mining Wastes," for review by the Environmental Engineering Committee (EEC) of EPA's Science Advisory Board (SAB). This report follows the introductory briefing we gave to the EEC on March 5, 1987. We intended to provide you with this report prior to today's meeting, however, further refinements to the work precluded advance distribution. Therefore, we are distributing the report at the meeting and presenting a summary of the methodology and results.

The general purpose of the risk screen is to supplement the on-going Mining Waste Regulatory Development Program (RDP). The first phase of the RDP is scheduled for completion in early October. In order to most successfully integrate the risk screen into the RDP, we would appreciate SAB review of this work to coincide with completion of the first phase of the RDP.

WHY WE CONDUCTED THE RISK SCREEN

When EPA issued the mining waste regulatory determination on July 3, 1986, the Agency stated its intention to develop risk-based management standards for mining waste under Subtitle D of RCRA. EPA also identified the need to supplement its existing mining waste information on waste generation, current waste management practices and the resulting environmental and human health problems. One vehicle for addressing these needs and helping to characterize mining waste problems and the scope of the mining waste regulatory program is the risk screen.

In particular, the risk screen serves several purposes.

- It will help EPA set priorities for collecting additional information necessary for developing the regulatory program;
- It can provide a context for performing analyses which lay out options for the scope of the regulatory program;
- It can help identify appropriate regulatory approaches for managing mining wastes; and
- It is an initial step in complying with Executive Order 12291 which requires the Agency to perform Regulatory Impact Analyses for major regulations.

HOW WE INTEND TO USE THE RESULTS

The risk screen is a preliminary assessment of human and ecological effects from mining operations and can be a valuable tool in the regulatory development process. Creating effective regulations for managing mining wastes depends on many factors, including our ability to obtain accurate information about the industry and its potential health and environmental effects. By systematically organizing existing information, and by identifying critical variables, the risk screen will allow the Agency to focus its data collection activities.

We realize that the results of the risk screen are not definitive but believe that they will provide useful information to help focus the regulatory effort, and help scope the regulations and regulatory options. In particuar, we can use the risk screen to assess the relative magnitude of environmental problems, by comparing results between mining segments and across exposure pathways.

SPECIFIC AREAS FOR SAB REVIEW

We are interested in SAB's examination of the risk screen methodology, and have identified four areas that we specifically request the board's expert review. The particular issues are:

1) Is the risk screen an appropriate tool given its intended uses and the quality of existing data?

2) Are there pathway/receptor combinations which we have not considered that may lead to significant human health exposure?

3) Is our use of a tiered approach appropriate to determine when constituents should be deleted from further analysis?

4) Are the assumptions we used for developing air emission factors appropriate given the purpose of the analysis?

Thank you for your help on this project. Please contact me if we can be of assistance during the review process.

Attachment

1) Sehmel, G. A. 1980. Particle Resuspension: A Review. Environmental Inter., 4:107-127.

2) Smith, W. J., F. W. Whicker, and H. R. Meyer. 1982. Review and Categorization of Saltation, Suspension, and Resuspension Models. Nuclear Safety Journal, 23(6):685-699.

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5) Bohn, Russel R., et al. 1983. Dust Control on Active Tailings Ponds. Environmental Services and Technology, Kansas City. NTIS PB83-216382, February.

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