

**EVALUATION STUDY OF THE MINE  
ENVIRONMENT NEUTRAL  
DRAINAGE PROGRAM (MEND)**

**MEND Project 5.9**

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Prepared for:

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and  
The MEND Secretariat  
Natural Resources Canada

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## *MEND Program Evaluation: Final Report*

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### *Foreword*

The consulting team wishes to acknowledge the vital cooperation of many people in the timely completion of this study. Our thanks are given to all those who willingly gave of their time to participate in the different phases of the survey, through personal or telephone interviews, or in some cases by collecting, collating and transmitting information from others or from their own records. We also wish to thank the MEND Secretariat for providing information and help throughout the study.

The contents of this report are the result of a five-month study conducted on the basis of an evaluation plan completed in October 1995 and a methodology report completed in February 1996. Readers should refer to these documents for appropriate background and context.

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## *Executive Summary*

### **Purpose**

The purpose of this evaluation is to report on the nine issues established by an evaluation plan approved by the Mine Environment Neutral Drainage program (MEND) Board of Directors, and in addition, to present findings on other important questions which arose during the course of the evaluation study.

### **Methodology**

The methodologies used to gather information and opinions on the evaluation issues, as well as other important questions for the study, consisted of four separate surveys, plus a review and analysis of pertinent documentation. The surveys covered MEND participants and associates, attendees at several MEND workshops, and a sample of junior mining companies.

### **Findings**

The study findings can be summarized by issue as follows:

*Issue 1: To what extent has MEND provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock?*

Before the establishment of MEND, many people in both industry and government knew of the existence of acid mine drainage, but most had no clear idea of how to solve the problem. Experiences at mine disposal sites were for the most part negative ones. MEND has produced a wide variety of useful knowledge and technology? essentially a toolbox of potential solutions. Among these are the use of water covers and dry covers for preventing AMD in both tailings and waste rock. A particularly important outcome has been the development of a common understanding among participants, inasmuch as it has allowed operators to take actions with greater confidence and to gain multi-stakeholder acceptance more quickly. Opportunities remain to establish definitive prediction methods, as well as to develop practical codes of practice which are acceptable within a legal framework.

*Issue 2: What has been MEND's contribution to reducing the harmful impacts on the environment of acid mine drainage?*

While, almost by definition, this question is impossible to answer in the short run, there are promising indications that MEND's efforts will help reduce harmful environmental impacts. We found a total of 17

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individual sites where such impacts have already been mitigated. In addition, MEND's work in the distribution of knowledge, stimulation of further technology developments, provision of examples of success, and improvement of general awareness both of the AMD problem and its potential solutions, are all expected to result in future reductions in harmful environmental impacts.

*Issue 3: Have MEND's R&D products resulted in net reduced costs associated with opening new mines, operating and closing existing mines, and in rehabilitating abandoned mine sites?*

MEND appears to have been successful in helping to reduce opening, operating and closing costs, at least in some instances, because of the increased confidence and reduced risk associated with the design and permitting phases. For five cases where respondents provided estimates of cost reductions due to MEND's work, the total savings amounted to approximately \$340 million. However, in some cases, costs may have been increased due to the improved knowledge MEND has provided about the real potential for AMD generation which otherwise might have gone unsuspected. MEND does not appear to have contributed as yet to cost reductions in the rehabilitation of abandoned or orphan sites, probably because relatively little is being spent on such efforts.

*Issue 4: In what manner and to what extent has MEND contributed to setting more realistic regulatory requirements, and to making the regulatory process less complex and more efficient?*

MEND has not had any direct effect upon the wording of regulations, but the knowledge and understanding it has produced have been incorporated into policy in at least two provinces. Its major and very significant impact has been in providing this information to all stakeholders, including operators, regulators and consulting engineers, and thereby reducing uncertainties and increasing confidence among all concerned; and by facilitating an improved relationship between operators and regulators so that now the behavioural norm is cooperation rather than confrontation. The complexity of the regulatory process has increased to some extent because of the increased and more sophisticated knowledge provided by MEND, but this knowledge has at the same time made it possible to manage the complexity.

*Issue 5: Has the design and delivery of MEND influenced its performance? What are the lessons learned?*

MEND serves as a strong internationally-recognized model of government-industry cooperation. The organizational structure and collaborative nature of the initiatives received unparalleled (in our experience) praise in this regard. Future opportunities exist to streamline MEND and to improve both its project management system and its outreach to non-participants, building on its record of collaboration to ensure continued positive, practically-focused work.

*Issue 6: To what extent have the technology transfer activities of MEND succeeded in informing the target audiences about the issues of acidic drainage and about the technologies which can deal with the problem? To what extent is decision-making on acid mine drainage now based more on science and technology considerations as a result of MEND?*

MEND has successfully reached its target audiences in the mining field with the efforts it has developed to date. The workshops MEND presents have been particularly successful: a comparison of the level of satisfaction of their participants with a standard benchmark, established for 20 Canadian technology centres, showed that MEND workshops scored higher than average. Decision-making on acid mine drainage is, at least to some extent, based more on scientific considerations, but sociological inputs probably remain pre-eminent. Future opportunities exist to more fully develop technology transfer products and services, and to ensure that all stakeholders, including non-operators such as environmental regulators, are fully informed about MEND's activities and outputs.

*Issue 7: Has MEND influenced the image and credibility of the mining industry regarding protection of the environment? In what manner and to what extent has MEND contributed to enhancing Canadian leadership internationally in the science and technology of the prevention of acid mine drainage?*

MEND has not attempted to exercise a public relations function, and perhaps as a result, has not influenced the general public's opinion of the mining industry to any significant extent. It has had a small positive effect upon some environmental groups, which however seem to retain a sceptical attitude toward the mining industry. On the other hand, MEND is credited for having considerably enhanced Canada's international reputation in this area, particularly because of the example it has set of commitment to solving the AMD problem and of cooperation among stakeholders. Opportunities still exist to improve the industry's image in the eyes of outsiders, but this perhaps should be left to the companies rather than to MEND.



*Issue 8: What should be MEND's focus until its anticipated completion in 1997?*

The three top priorities identified through our consultations with stakeholders were:

- to finish up current projects and outstanding work and to plan for future efforts, so as not to lose the impetus and momentum that has been generated over the past years;
- to complete and publish an integrated manual covering the entire range of acid mine drainage topics, so as to provide a practical and useful code or handbook of knowledge and practices for acceptable mine design and operation; and
- to continue and extend the existing technology transfer initiatives.

*Issue 9: Is there unfinished business or changing circumstances that would suggest a need for future phases of MEND beyond 1997? If so, how should MEND be constructed and delivered, and what are the cost implications?*

There appears to be significant unfinished business warranting continued collaborative efforts in AMD research; a few examples are biological effects and treatment methods, long-term behaviour of covers, and prediction modelling. Most of those we consulted favoured an ongoing program such as MEND, featuring the dissemination of information by personal contacts (workshops, conferences, etc.), as well as through an organized and systematic data communication system which would include both electronic media and traditional printed reports. The preferred organization was a scaled-down committee structure with a secretariat or central staff group roughly the size of the present one. Most considered that all the existing stakeholders should continue to participate and to provide funding (at the current level or somewhat lower), but that industry should be prepared to pay all costs if absolutely necessary.

## **Overall Conclusions**

Our study found that MEND has developed an exemplary model of public-private cooperation which has fostered increased cooperation and confidence in the Canadian mining sector and marketplace, with respect to acid mine drainage prevention and treatment. (See **Appendix F** for a description of MEND's role in Canada's mining technology infrastructure.) This has led to some significant early benefits in mining operation cost reductions and improved environmental protection practices, though a longer time frame for evaluation will be required to judge the full economic and environmental impacts.

In integrating the unsolicited comments from interviewees and from the associates, we found that **the bottom line was a solid vote of confidence for the way MEND has been structured and managed, and particularly for the committee officers and the Secretariat.** Irrespective of what respondents thought the next step should be, they were generally very favourable toward the existing organization.

An opportunity exists to build on the positive relationships fostered by MEND to continue to seek to pursue AMD science-related issues, technology transfer, and an improved regulatory environment. **Figure 1** on the following page summarizes findings by the performance framework established for the program at the outset of the study.

**The recommendations of this evaluation study are discussed under section 5.0, Recommendations.**

Figure 1: Summary of MEND Program Performance

HOW?			WHO?	WHAT do we want?	6	WHY?
inputs	activities	outputs	users / stakeholders	direct (program) outcomes	intermediate outcomes	long-term (policy) outcomes
Prediction, Prevention and Control, Treatment, Monitoring <ul style="list-style-type: none"> <li>• committee meetings</li> <li>• literature surveys</li> <li>• field trials                             <ul style="list-style-type: none"> <li>- technical reports</li> <li>- MEND manuals</li> <li>- published papers</li> </ul> </li> </ul> New Ideas <ul style="list-style-type: none"> <li>• unsolicited proposals</li> <li>• informal discussions</li> </ul> Technology Transfer <ul style="list-style-type: none"> <li>• workshops</li> <li>• videos</li> <li>• technical reports</li> <li>• MEND manuals</li> <li>• published papers</li> </ul>			MEND participants and associate participants <ul style="list-style-type: none"> <li>• mining companies</li> <li>• mining associations</li> <li>• regulatory bodies</li> <li>• consulting engineers</li> <li>• universities</li> <li>• government researchers</li> </ul> Primarily non-MEND participants, but also participants, associate participants, and the general public <ul style="list-style-type: none"> <li>• mining companies</li> <li>• mining associations</li> <li>• regulatory bodies</li> <li>• consulting engineers</li> <li>• universities</li> <li>• government researchers</li> <li>• general public</li> <li>• NGOs/environmental groups</li> </ul>	Improved networking and communication among MEND participants (UU)  Increased and improved awareness, understanding and knowledge about possibilities and methodologies for reducing acid mine drainage (U)  Changes in regulations and requirements for approvals of mine opening and closing (U?)  Changes in plans and designs for handling mine tailings and waste rock (U)  Reduced liabilities - less of a bond required to open sites (U?)	Improved confidence in the prediction of long-term management requirements for reactive tailings and waste rock (U)  Established techniques for operation and closure of acid-generating tailings and waste rock disposal areas in a manner which is: <ul style="list-style-type: none"> <li>• predictable (U)</li> <li>• timely (U)</li> <li>• affordable (U)</li> <li>• environmentally sensitive</li> </ul> Shortened time to opening mines and mills; increased employment in mid-term; faster return on investment for mine owners (U?)  Reduced likelihood of AMD contamination of surface and groundwater (U TE)	Significantly reduced long-term costs for closing mine and mill sites (TE)  Significantly reduced impacts on the environment as a result of mining activity (TE)  Increased public confidence in the environmental responsibility of the mine industry (TE)

Key:  
 U = positive impact  
 ? = uncertain impact  
 - = negative impact  
 TE = too early

## ***Résumé***

### **But**

Ce document d'évaluation fait le point sur les neuf questions retenues dans un plan d'évaluation approuvé par le conseil d'administration du Programme de neutralisation des eaux de drainage dans l'environnement minier (PNEDEM). De plus, il présente le fruit de nos réflexions sur d'autres questions importantes qui se sont posées au cours de l'évaluation.

### **Méthodologie**

Pour recueillir de l'information et des points de vue sur les questions soumises à l'évaluation, et sur d'autres questions importantes pour l'étude, on a procédé à quatre sondages distincts, en plus d'un examen et d'une analyse de la documentation pertinente. Les sondages ont été faits auprès des participants en titre et des participants associés au PNEDEM, des personnes qui ont assisté aux nombreux ateliers du PNEDEM et d'un groupe représentatif de petites entreprises minières.

### **Résultats**

Voici un résumé des résultats obtenus pour chacune des questions posées :

*Question 1: Dans quelle mesure le PNEDEM a-t-il fourni à l'industrie minière des données scientifiques, techniques et économiques suffisamment étoffées pour lui permettre de prévoir les besoins à long terme en matière de prévention et de traitement des stériles et résidus réactifs?*

Avant la création du PNEDEM, le problème du drainage minier acide était largement connu dans l'industrie et au sein des instances gouvernementales, mais bien peu avaient une idée précise de la façon de le résoudre. Les expériences réalisées dans des aires d'évacuation de déchets avaient échoué pour la plupart. Le PNEDEM a produit des connaissances et des technologies aussi utiles que variées, qui offrent une panoplie de solutions possibles. Au nombre de ces solutions figurent des couvertures sèches et aqueuses qui préviennent le drainage minier acide dans les stériles et les résidus. Le PNEDEM a créé une communauté d'idées qui a permis aux exploitants d'agir avec davantage de confiance et d'obtenir plus rapidement l'adhésion des autres intervenants. Il reste à établir des méthodes de prévision plus sûres et à élaborer des codes de pratique acceptables dans un cadre juridique.

*Question 2: En quoi le PNEDEM a-t-il contribué à réduire les effets nocifs du drainage minier acide sur l'environnement?*

Bien qu'il soit difficile de répondre à cette question, vu le jeune âge du programme, il y a tout lieu de croire que le PNEDEM aidera à réduire les effets néfastes du drainage minier acide sur l'environnement. Nous avons dénombré 17 sites où les impacts ont déjà été atténués. En outre, les efforts qui se

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poursuivent dans le cadre du PNEDEM pour diffuser les connaissances, stimuler le développement de technologies, montrer des exemples de réussite et, de façon générale, mieux faire connaître la problématique du drainage minier acide et les solutions possibles contribueront sans doute à réduire davantage les effets nocifs sur l'environnement.

*Question 3 : La recherche-développement effectuée dans le cadre du PNEDEM a-t-elle permis une réduction nette des coûts d'ouverture, d'exploitation et de fermeture des mines, et des coûts de restauration des sites miniers abandonnés?*

Le PNEDEM a apparemment contribué à réduire les coûts d'ouverture, d'exploitation et de fermeture des mines, du moins dans certains cas, ce que l'on attribue à la diminution de la part de risques et d'incertitudes au moment de la conception des travaux et de l'attribution des permis. Dans cinq cas, les répondants ont fourni une estimation des réductions de coûts attribuables aux travaux du PNEDEM, qui représentent globalement des économies d'environ 340 millions de dollars. Le PNEDEM a peut-être, dans certains cas, eu pour effet d'augmenter les coûts en portant à la connaissance des exploitants un risque de drainage minier acide qui aurait échappé à leur attention autrement. Par ailleurs, le PNEDEM ne semble pas avoir contribué à réduire les coûts de restauration des sites abandonnés ou orphelins, probablement parce que l'on investit encore relativement peu dans ce type de travaux.

*Question 4 : En quoi et dans quelle mesure le PNEDEM a-t-il contribué à adapter les règlements à la réalité et à rendre le processus de réglementation moins complexe et plus efficace?*

Si le PNEDEM n'a eu aucun effet direct sur la formulation des règlements, il a, en revanche, produit des données et des connaissances qui ont été intégrées aux politiques dans au moins deux provinces. Sa contribution la plus importante a été de fournir cette information à tous les intervenants, notamment les exploitants, les organismes de réglementation et les ingénieurs-conseils, et, ainsi, de dissiper les doutes et d'augmenter la confiance chez tous les intervenants; il a facilité le resserrement des liens entre exploitants et organismes de réglementation, de telle sorte que dans les mentalités, la confrontation a fait place à la collaboration. Le processus de réglementation a gagné en complexité dans la mesure où les données produites par le PNEDEM sont de plus en plus volumineuses et sophistiquées, mais ces connaissances portent en elles la capacité de gérer la complexité.

*Question 5 : La façon dont le programme est conçu et exécuté a-t-elle un effet sur le rendement du PNEDEM? Quelles leçons a-t-on tirées de l'expérience?*

Le PNEDEM est un modèle de collaboration entre le gouvernement et l'industrie, qui jouit maintenant

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d'une renommée internationale. Sa structure organisationnelle et l'importance qu'il attache à la collaboration lui ont valu des éloges qui, à notre connaissance, n'ont pas d'équivalent. Il est encore possible de rationaliser le PNEDEM, d'améliorer le système de gestion de projets et de diffuser de l'information à des non-participants, de tirer profit des relations de collaboration déjà établies pour continuer à axer les efforts sur des applications pratiques.

*Question 6 : Dans quelle mesure les activités de transfert technologique réalisées dans le cadre du PNEDEM ont-elles contribué à informer les publics cibles sur la problématique du drainage acide et les technologiques pouvant aider à la résoudre? Jusqu'à quel point le PNEDEM a-t-il contribué à donner plus de poids aux sciences-technologies dans les décisions prises en matière de drainage minier acide?*

Par les efforts qu'il a suscités jusqu'à maintenant, le PNEDEM a réussi à atteindre les publics visés dans le secteur minier. Les ateliers qu'il présente ont été particulièrement utiles. Si l'on compare le degré de satisfaction des participants à la moyenne obtenue pour une vingtaine de centres technologiques canadiens, on constate que les ateliers du PNEDEM se classent au-dessus de la moyenne. Les décisions prises en matière de drainage minier acide s'appuient davantage sur des données scientifiques, du moins dans une certaine mesure, mais les facteurs sociologiques continuent probablement à prédominer. Il est possible de développer davantage les produits et services servant au transfert des technologies et de faire en sorte que tous les intervenants, exploitants et non-exploitants, comme les organismes de réglementation environnementale, soient parfaitement au courant des activités et des résultats du PNEDEM.

*Question 7 : Le PNEDEM a-t-il eu une influence sur l'image et la crédibilité de l'industrie minière en ce qui concerne la protection de l'environnement? De quelle façon et dans quelle mesure a-t-il contribué à accentuer le leadership international du Canada dans la science et la technologie de la prévention du drainage minier acide?*

Le PNEDEM n'a joué aucun rôle sur le plan des relations publiques, et c'est pourquoi il n'a peut-être pas exercé une influence importante sur la façon dont l'industrie minière est perçue dans l'opinion publique. Il a eu un léger impact positif sur certains groupes environnementaux, qui n'en demeurent pas moins sceptiques à l'égard de l'industrie minière. En revanche, il a le mérite d'avoir considérablement rehaussé la réputation internationale du Canada dans ce domaine; il est devenu un modèle, tant par sa détermination à résoudre le problème du drainage minier acide que par la collaboration qu'il encourage entre les intervenants. Il est encore possible d'améliorer l'image de l'industrie à l'étranger, mais les efforts en ce sens ne relèvent pas tant du PNEDEM que des entreprises elles-mêmes.

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*Question 8 : Sur quoi le PNEDEM devrait-il concentrer ses efforts d'ici à ce qu'il termine ses activités (en 1997)?*

Nos consultations avec les parties intéressées nous ont permis de dégager les trois priorités suivantes :

- terminer les projets en cours et les travaux en suspens, et planifier la relève du programme de manière à poursuivre sur sa lancée;
- rédiger et publier un manuel couvrant sous tous ses angles la question du drainage minier acide, qui puisse servir de code, d'ouvrage de référence et de guide pratique aux concepteurs et aux exploitants miniers; et
- poursuivre et augmenter les activités de transfert technologique.

*Question 9 : Y a-t-il des travaux inachevés ou une nouvelle donne qui justifieraient de poursuivre le PNEDEM au-delà de 1997? Dans l'affirmative, comment devrait-on concevoir et exécuter cette nouvelle phase, et quels en seraient les coûts?*

Il y a, semble-t-il, des travaux inachevés dont l'importance justifierait la poursuite des recherches entreprises en collaboration sur le drainage minier acide; mentionnons, à titre d'exemple, les effets biologiques des méthodes de traitement, le comportement à long terme des couvertures, et l'élaboration des modèles prévisionnels. La plupart des intervenants que nous avons consultés sont en faveur de l'idée de conserver un programme comme le PNEDEM, dans lequel de l'information serait diffusée au moyen de contacts personnels (au cours d'ateliers, de conférences, etc.) et au moyen d'une méthode systématique et structurée de communication de données qui ferait appel autant à l'électronique qu'à l'imprimé. À cet égard, les gens consultés privilégient une structure constituée de comités plus petits et moins nombreux, organisés autour d'un secrétariat ou d'un groupe central qui aurait à peu près la même taille que le secrétariat actuel. De l'avis de la plupart, tous les intervenants actuels devraient continuer à participer au programme et à le financer (au niveau actuel ou à un niveau légèrement inférieur), mais l'industrie devrait être prête à payer tous les coûts si c'est absolument nécessaire.

### **Conclusions générales**

Notre étude démontre que le PNEDEM a établi un modèle de collaboration entre les secteurs public et privé, et que, grâce à son exemple, la collaboration et la confiance dans les possibilités de prévention et de traitement du drainage minier acide ont augmenté dans l'industrie minière canadienne et sur le

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marché. (L'**Appendice F** décrit la contribution du PNEDEM au développement de l'infrastructure technologique dans l'industrie minière canadienne.) Déjà, le PNEDEM a produit des résultats tangibles; il a permis de réduire les coûts d'exploitation minière et d'améliorer la protection de l'environnement. Cela dit, il faudra attendre encore un certain temps pour être en mesure d'évaluer pleinement les retombées économiques et environnementales du programme.

À partir des commentaires qui nous ont été faits spontanément par les intervenants consultés et les participants associés, **il ressort essentiellement que les gens sont satisfaits de la structure et du mode de gestion du PNEDEM, et en particulier du travail accompli par les comités et le secrétariat.** Peu importe l'opinion des répondants sur la suite du programme, la plupart se sont montrés très favorables à l'organisation actuelle.

Nous pouvons continuer à mettre à profit les relations de travail positives qui se sont établies sous l'impulsion du PNEDEM et poursuivre les efforts entrepris pour résoudre les problèmes scientifiques posés par le drainage minier acide, assurer le transfert des technologies et améliorer la réglementation. Dans le tableau de la page suivante (**figure 1**), nous avons indiqué dans quelle mesure le PNEDEM satisfait aux critères de rendement établis au début de notre étude.



Figure 1 : Données sommaires sur le rendement du PNEDEM

COMMENT?			QUI?	QUOI?	6	POURQUOI?
intrants	activités	extrants	utilisateurs/intervenants	résultats directs (programme)	résultats à moyen terme	résultats à long terme (politique)
<p>Prévision, prévention et limitation, traitement, contrôle</p> <ul style="list-style-type: none"> <li>• réunions en comité</li> <li>• recherches documentaires</li> <li>• essais sur le terrain                             <ul style="list-style-type: none"> <li>- rapports techniques</li> <li>- manuels PNEDEM</li> <li>- publications</li> </ul> </li> </ul> <p>Nouvelles idées</p> <ul style="list-style-type: none"> <li>• propositions non sollicitées</li> <li>• discussions informelles</li> </ul> <p>Transfert de technologies</p> <ul style="list-style-type: none"> <li>• ateliers</li> <li>• vidéos</li> <li>• rapports techniques</li> <li>• manuels PNEDEM</li> <li>• publications</li> </ul>			<p>Participants au PNEDEM et associés</p> <ul style="list-style-type: none"> <li>• sociétés minières</li> <li>• associations minières</li> <li>• organismes de</li> <li>• ingénieurs-conseils</li> <li>• universités</li> <li>• chercheurs du secteur public</li> </ul> <p>Surtout non-participants, mais aussi participants, associés et grand public</p> <ul style="list-style-type: none"> <li>• sociétés minières</li> <li>• associations minières</li> <li>• organismes de</li> <li>• ingénieurs-conseils</li> <li>• universités</li> <li>• chercheurs du secteur public</li> <li>• grand public</li> <li>• ONG/groupes</li> </ul>	<p>Communication et réseautage améliorés entre les participants au PNEDEM (UU)</p> <p>Connaissance accrue et meilleure compréhension des possibilités et des méthodes de réduction du drainage minier acide (U)</p> <p>Changements apportés à la réglementation et aux conditions d'approbation des ouvertures et fermetures de mines (U?)</p> <p>Changements apportés aux plans de traitement des résidus et stériles (U)</p> <p>Diminution des obligations financières - réduction des garanties exigées pour ouvrir des sites (U?)</p>	<p>Confiance accrue dans la prévision des besoins à long terme en matière de gestion des résidus et des stériles réactifs (U)</p> <p>Techniques établies pour l'exploitation et la fermeture de zones d'évacuation de résidus et de stériles acidogènes d'une manière</p> <ul style="list-style-type: none"> <li>• prévisible (U)</li> <li>• rapide (U)</li> <li>• abordable (U)</li> <li>• écologique (U?)</li> </ul> <p>Raccourcissement des délais d'ouverture des mines et des usines; augmentation des emplois à moyen terme; rentabilisation plus rapide pour les propriétaires des mines (U?)</p> <p>Réduction du risque de contamination de la surface et des eaux souterraines par le drainage minier acide (U TE)</p>	<p>Réduction considérable des coûts à long terme de la fermeture des mines et des usines (TE)</p> <p>Réduction considérable des effets de l'activité minière sur l'environnement (TE)</p> <p>Confiance accrue du public dans le sens des responsabilités de l'industrie minière en matière d'environnement (TE)</p>

Symboles :

- U = impact positif
- ? = impact incertain
- = impact négatif

TE = trop tôt pour le dire

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**ÉVALUATION DU PROGRAMME DE NEUTRALISATION DES EAUX DE DRAINAGE  
DANS L'ENVIRONNEMENT MINIER (PNEDEM)**

**Résumé des recommandations**

**1. Transfert de technologies**

**1.1** Le PNEDEM devrait étendre et augmenter ses produits et services de transfert technologique. En particulier, il devrait continuer à offrir et à promouvoir activement des ateliers régionaux; il devrait aussi produire et diffuser dans le plus bref délai un manuel complet du drainage minier acide.

**2. Priorités d'ici la fin du programme**

**2.1** Le PNEDEM devrait s'employer tout d'abord à mener à terme les projets inachevés et, ensuite, à documenter et à diffuser les résultats de toutes les études terminées. Les résultats devraient être présentées sous une forme conviviale.

**3.0 Travaux inachevés et succession du PNEDEM**

**3.1** Il faudrait concevoir et mettre en place un programme semblable au PNEDEM afin de poursuivre les études déjà commencées sur certains aspects du drainage minier acide, notamment les effets biologiques du drainage minier acide, les méthodes de traitement biologique, le comportement à long terme des couvertures ainsi que les techniques de prévision applicables aux nouvelles mines et aux aires d'évacuation des déchets qui existent déjà.

**3.2** Ce nouveau programme devrait avoir une structure organisationnelle comparable à celle du PNEDEM, mais il faudrait envisager de réduire le nombre et la taille des comités (administratifs et techniques). Il faudrait faire usage des moyens de communication électroniques.

**3.3** Ressources naturelles Canada devrait continuer à exercer la fonction de secrétariat avec un budget du même ordre de grandeur et, dans la mesure du possible, sans solution de continuité dans le transfert de l'information.

**3.4** Tous les conseils et comités devraient compter parmi leurs membres des représentants de la population scientifique du gouvernement fédéral, des organismes de réglementation fédéraux et provinciaux, des petites et grandes entreprises minières, des universités et des consultants.

**3.5** Le financement du nouveau programme devrait dépendre des projets de recherche retenus (de l'ordre de million(s) de dollars par année), et tous les partenaires majeurs devraient y participer. Les partenaires devraient s'entendre sur un budget pluriannuel, afin de planifier les projets à long terme.

Il faudrait songer à une formule de financement dans laquelle environ soixante-quize pour cent du financement proviendrait de l'industrie, et le reste des autres partenaires.

#### **4.0 Leçons de l'expérience**

**4.1** Le PNEDEM et tout programme qui lui succédera doivent continuer à faire participer autant d'intervenants que possible aux recherches, aux discussions et aux décisions.

**4.2** Le secrétariat du PNEDEM doit contrôler de plus près la gestion des projets de recherche et signaler promptement au comité de gestion les retards et les cas d'inefficacité.

## ***1.0 MEND Performance Framework***

The MEND Program is a cooperative research program that is sponsored, financed, and administered by a voluntary consortium consisting of the mining industry, the Government of Canada, and eight provincial governments. The program develops technology to prevent and control acid mine drainage which is considered to be the largest environmental liability facing the mining industry.

A comprehensive profile of MEND is contained in the Proposal for an Evaluation Study of the Mine Environment Neutral Drainage (MEND) Program, October 1995. For the purposes of our analysis, we developed a performance framework in conjunction with Natural Resources Canada, the Mining Association of Canada, and MEND Board project authorities to describe **HOW** MEND spent resources, carried on activities, and produced outputs; **WHO** the Program has worked with in terms of users and stakeholders; **WHAT** the program was intended to achieve; and, **WHY** in terms of direct, intermediate, and longer-term outcomes and impacts. **Figure 2**, on the following page, describes the framework.

Figure 2: Performance Framework for the MEND Program

HOW?			WHO?	WHAT do we want?	6	WHY?
inputs	activities	outputs	users / stakeholders	direct (program) outcomes	intermediate outcomes	long-term (policy) outcomes
Prediction, Prevention and Control, Treatment, Monitoring <ul style="list-style-type: none"> <li>committee meetings</li> <li>literature surveys</li> <li>field trials                             <ul style="list-style-type: none"> <li>technical reports</li> <li>MEND manuals</li> <li>published papers</li> </ul> </li> </ul> New Ideas <ul style="list-style-type: none"> <li>unsolicited proposals</li> <li>informal discussions</li> </ul> Technology Transfer <ul style="list-style-type: none"> <li>workshops</li> <li>videos</li> <li>technical reports</li> <li>MEND manuals</li> <li>published papers</li> </ul>			MEND participants and associate participants <ul style="list-style-type: none"> <li>mining companies</li> <li>mining associations</li> <li>regulatory bodies</li> <li>consulting engineers</li> <li>universities</li> <li>government researchers</li> </ul> Primarily non-MEND participants, but also participants, associate participants, and the general public <ul style="list-style-type: none"> <li>mining companies</li> <li>mining associations</li> <li>regulatory bodies</li> <li>consulting engineers</li> <li>universities</li> <li>government researchers</li> <li>general public</li> <li>NGOs/environmental groups</li> </ul>	Improved networking and communication among MEND participants  Increased and improved awareness, understanding and knowledge about possibilities and methodologies for reducing acid mine drainage  Changes in regulations and requirements for approvals of mine opening and closing  Changes in plans and designs for handling mine tailings and waste rock  Reduced liabilities - less of a bond required to open sites	Improved confidence in the prediction of long-term management requirements for reactive tailings and waste rock  Established techniques for operation and closure of acid-generating tailings and waste rock disposal areas in a manner which is: <ul style="list-style-type: none"> <li>predictable</li> <li>timely</li> <li>affordable</li> <li>environmentally sensitive</li> </ul> Shortened time to opening mines and mills; increased employment in mid-term; faster return on investment for mine owners  Reduced likelihood of AMD contamination of surface and groundwater	Significantly reduced long-term costs for closing mine and mill sites  Significantly reduced impacts on the environment as a result of mining activity  Increased public confidence in the environmental responsibility of the mine industry

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Users, direct and intermediate outcomes were the primary focus of this evaluation.

As noted in the following section, the focus of this study has been to establish whether MEND reached the key targeted users and stakeholders and whether it achieved the direct and intermediate outcomes established at its inception and logically connected to its long-term goals. From this framework for data collection and analysis, our report addresses nine evaluation issues laid out by the project authorities. (See Methodology Report, February 1996.) The nine issues include:

Issue 1: To what extent has MEND provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock?

Issue 2: What has been MEND's contribution to reducing the harmful impacts on the environment of acid mine drainage?

Issue 3: Have MEND's R&D products resulted in net reduced costs associated with opening new mines, operating and closing existing mines, and in rehabilitating abandoned mine sites?

Issue 4: In what manner and to what extent has MEND contributed to setting more realistic regulatory requirements, and to making the regulatory process less complex and more efficient?

Issue 5: Has the design and delivery of MEND influenced its performance? What are the lessons learned?

Issue 6: To what extent have the technology transfer activities of MEND succeeded in informing the target audiences about the issues of acidic drainage and about the technologies which can deal with the problem? To what extent is decision-making on acid mine drainage now based more on science and technology considerations as a result of MEND?

Issue 7: Has MEND influenced the image and credibility of the mining industry regarding protection of the environment? In what manner and to what extent has MEND contributed to enhancing Canadian leadership internationally in the science and technology of the prevention of acid mine drainage?

Issue 8: What should be MEND's focus until its anticipated completion in 1997?

Issue 9: Is there unfinished business or changing circumstances that would suggest a need for future phases of MEND beyond 1997? If so, how should MEND be constructed and delivered, and what are the cost implications?



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## **2.0 Methodologies**

The methodologies used to gather information and opinions on the evaluation issues, as well as other important questions for the study, consisted of four separate surveys, plus a review and analysis of pertinent documentation.

### **2.1 Personal Interviews of MEND Participants and Non-participants**

The cornerstone of this evaluation study was an extensive and intensive survey of the main MEND participants, associates and other stakeholders. Included were mining companies, federal and provincial departments involved in MEND, industry associations, consulting engineering companies, environmental groups, and experts from academia and foreign organizations. The survey was designed to ensure that members of the MEND Board of Directors, Management Committee, and technical committees were adequately represented.

We conducted 50 personal interviews with a total of 58 individuals across Canada (including one in the United States), either face to face or in a few cases by telephone. The breakdown among individual respondents by organizational category is as follows:

Industry	19
Federal government	9
Provincial government	13
Mining associations	4
Consulting engineers	9
Environmental groups	1
Other experts	3
<b>Total</b>	<b>58</b>

Representatives from industry and governments were identified in the first instance from attendance lists at meetings of the MEND Board of Directors and Management Committee. Other names were added from the formal membership lists of these two groups. An effort was made to reach all possible participants, or at least representatives of participating organizations. In practice, personal schedules and availability prevented some members from being interviewed. In the final analysis, 50% of the Board of Directors, 81% of the Management Committee and 37% of members of the technical committees were interviewed.

In addition to those mentioned above, representatives of the Canadian, Québec, Ontario and British Columbia Mining Associations were interviewed, as were a total of nine consulting engineers. It was unfortunate that repeated efforts to interview representatives of environmental groups resulted in only one interview. Finally, three interviews were conducted with other experts from Canada and the USA.

Given the depth of experience and level of responsibility of the individuals who were interviewed, we consider the survey respondents to be both representative and authoritative in their opinions and comments.

## **2.2 *Fax Survey of MEND Associates***

The MEND Secretariat provided a list of Associates who advise on the research program and review the technical reports that result from MEND projects. Of the 21 names on this list, two were found to have already been included in the Main Survey. An abridged version of the survey questions was faxed to the remaining 19 Associates, who were located in Canada, the United States, Europe and Australia. Some follow-up telephone calls were made in an effort to encourage a wide response. Of the 15 who received the fax (the remaining four fax numbers were apparently incorrect or inoperative), six responded to the survey, either by fax or by e-mail. Two responses were received from Canadian associates, two from the USA, one from Ireland and one from Australia.

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### **2.3 *Reach Analysis of Canadian Mining Operations with AMD Potential: Telephone Survey of Junior Mining Companies***

As part of the evaluation, we examined the effectiveness with which MEND's results are being communicated to junior mining companies, which generally are not participants in MEND but which may well have current or potential problems with acid mine drainage. The questions put to these respondents were designed to determine the degree to which knowledge about MEND, or about the results obtained by MEND, had reached the juniors or had been assimilated by them. Thus, the responses would have relevance to some, but not all, of the main issues identified by the project authority.

To select as many such "clients" as possible, we used the following methodology. First, over 100 Canadian mining operations were identified as having acid mine drainage potential, using data obtained from the Geological Survey of Canada and from the *Canadian Mines Handbook ? 1994-95* (copyright Southam Magazine Group, 1994). From this list, those already known by the consultant to be involved with MEND in a formal way (through project participation, committee memberships, etc.) were set aside. The remaining list of 44 companies were then reviewed with the MEND Secretariat: some were identified as currently being defunct or in a different line of business; others were struck from the list because of their known lack of AMD potential or because of their known involvement with MEND. This process resulted in a population of 30 mining operations, with head offices located mostly in either Vancouver or Toronto, and a few in each of Northern Québec, Northern Ontario, Montréal, the Yukon Territory, or Saskatchewan. The initial plan was to interview about one-third of the total, with random sampling until the desired quota of interviews had been achieved. The actual result was that almost half of the companies either had out-of-service or unknown telephone numbers, had merged or disappeared from the mining world, or did not return calls. Eventually, 16 representatives of junior mining companies were contacted. The results of this telephone survey are described in **section 3.6.2**, and reported in detail in **Appendix D**.

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#### **2.4 Telephone Survey of MEND Workshop Attendees**

The MEND Secretariat provided a list of 96 individuals who had attended one or more of three MEND workshops presented during 1995. The distribution of attendees at the different events is shown in the following table.

<b>Workshop Location and Date</b>	<b>No. Attendees</b>
Montréal, December 7/8, 1995	29
Sudbury, October 4/5, 1995	35
Sydney, June 21/22, 1995	32
<b>Total</b>	<b>96</b>

An attempt was made to telephone every individual on this list, with the result of 51 responses to the survey. The questionnaire addressed the extent to which the workshops had successfully met the needs and requirements of the attendees. Thus, as in the case of the telephone survey of junior mining companies described in section 2.3 above, the responses to this survey had relevance to some of the main issues addressed by the personal interviews of the Main Survey, but not to all the issues.

#### **2.5 Literature Review**

An extensive literature review of MEND project reports, plans and independent analyses was conducted throughout the study.

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**2.6 Acronyms and other terminology used in this Report**

AETE	Aquatic Effects Technology Evaluation Program
AQUAMIN	The Assessment of the Aquatic Effects of Mining in Canada
AMD	Acid Mine Drainage
ARD	Acid Rock Drainage
CAMIRO	Canadian Mining Industry Research Organization
CANMET	Canada Centre for Mineral and Energy Technology
FTE	Full Time Equivalent (the equivalent of one person working full-time)
MEND	Mine Environment Neutral Drainage
MIROC	Mining Industries Research Organization of Canada
MITEC	Mining Industry Technology Council of Canada
MRD	Mining Research Directorate
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
Respondents	Interviewees; individuals responding to questions
Responses	Answers given by respondents (note that one respondent may give more than one response)

### **3.0 Issues Identified by the MEND Board of Directors**

#### **3.1 Industry's capability to handle AMD**

*Issue 1: To what extent has MEND provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock?*

##### **3.1.1 Personal Interviews**

Although the issue as stated contains the key word "predict", we found that interviewees tended to consider all facets of the AMD problem in answering the question: in addition to prediction, they were talking about prevention, control, monitoring, treatment? in fact, all aspects of the AMD problem. We recorded their answers as given.

We began by seeking the views of respondents on the "pre-MEND" situation: we asked if they thought their company (or the mining industry in general) had the ability, before MEND came into being, to predict the long-term behaviour of tailings and waste rock disposal sites, with any sense of confidence that the predictions would be valid. Of the 46 who responded to the question, 23 told us that industry knew of the problem but not the solution. A typical comment:

*"In the 1970's AMD was little understood, lime treatment was primitive, and vegetation was believed to control AMD generation. Prediction was hampered by both the lack of technical understanding of AMD generation and the crudity of models and computers. In the 1980's ... governments and companies both underestimated the importance and complexity of dealing with AMD."*

But we also received answers both more positive, and more negative, than this response. On the one hand, ten of the interviewees said they thought there was essentially no understanding of the problem. For example:

*"Didn't really know what they were doing. Lot of assumptions were being made. Rehabilitation was aimed at cosmetic results, not really at AMD. Basic lack of understanding."*

But on the contrary seven respondents stated that *both* the problem and the solution were known and understood, but that this knowledge had simply not been applied by the mining companies:

*"AMD was understood and known before MEND."*

*"Water covers were known but not accepted by regulators."*

*"Industry knew about the problem. In the 70s there was a lot of waterways damage, so everybody knew about ARD. CANMET knew about, and was working on, the problem in 1975."*

We also asked what sort of experience existed in disposing of acid-generating tailings or waste rock. A total of about thirty Canadian mine sites were named by respondents – seven being identified by two or more interviewees – as examples of attempts to cope with acid mine drainage. Most of them were viewed as unsuccessful. Some typical comments:

*"At [a mine near Timmins, ON] abandoned tailings site is leaching into a lake. But this is not really as bad a situation as it looks: the water system downstream is fairly alkaline and thus is neutralizing the acid drainage."*

*"At [a site in New Brunswick], they backfilled rock into a different hole. It began to acidify and cook, eventually bursting into spontaneous combustion: still burning after 25 years. They also have a tailings pile hundreds of hectares in extent, and several storeys high, being handled through collection and treatment of drainage water."*

When we asked what sort of results MEND has produced that should lead to more successes, or fewer problems in the future, 44 respondents answered this question. Of these, 20 did not identify any specific breakthroughs, but said that the broad spectrum of results obtained by MEND should be useful in attacking the AMD problem. Two brief quotes:

*"MEND produced a toolbox of potential solutions."*

*"MEND has discounted the bad technologies."*

Underwater disposal was seen by 17 respondents as the most promising single technology demonstrated, and six interviewees pointed to dry covers as a useful result. A pithy comment on the advantages of water covers:

*"Water cover ain't a stupid idea. The tailings must be kept anaerobic: so "high and dry" is in fact the worst possible treatment. Revegetating may have worsened the problem (because of improved aeration of the tailings beneath the topsoil)."*

We tried to probe for respondents' views on the positive and negative outcomes of MEND. Among the responses received, 27 identified positive outcomes and 11 were negative outcomes. On the positive side, 12 interviewees cited the provision of valuable technical information to both industry and government, while 11 pointed to the promotion of a cooperative attitude on both sides:

*"...it has fostered a proactive, forward looking philosophy; has produced common understanding between industry and government."*

*"MEND has coopted the naysayers and involved them in finding solutions to the problem (in particular among the regulators and public interest groups)."*



Four respondents suggested other benefits, among them increased credibility for Canadian industry in other countries, and increased awareness of the AMD situation within Canada. These points are expanded further in section 3.7 of this Report. One respondent offered the following insight:

*"The dollar value of MEND accomplishments is difficult to quantify. What is unarguable is that the research was much more cost effective because of the focused approach and the combined efforts."*

A total of eleven respondents identified some negative outcomes of MEND: two pointed out that some projects were too site-specific for their results to be applicable elsewhere; two other interviewees said that MEND was sometimes too much driven by conventional wisdom (for example, it focused to a certain extent on wetlands or wet covers as curealls, sometimes to the extent of excluding other options *a priori*); a further two respondents complained that MEND had failed to disseminate adequately the valuable information it had produced, or to educate senior government managers about the importance of the program's thrust; and three officials in different provinces stated that some participants were now finding themselves exhausted by a heavy load of committee work, or disappointed because their initial high expectations had not been fulfilled, or simply burdened by the realization of the difficulties being faced. Another provincial official said:

*"MEND has emphasized the development of techniques for reducing restoration costs, rather than reducing environmental impacts. Better rehabilitation techniques, at lower costs, do not necessarily reduce environmental impacts. These environmental aspects have not been given much attention in MEND's research projects."*

Finally, one respondent commented that MEND had to some extent "usurped" or displaced the indigenous provincial organization in British Columbia:

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*"The national organization took over from what had been an active regional group."*

We raised the question of the adequacy of MEND's reports, first, on the technical or scientific level. The responses to this question were generally very similar to each other, but with minor variations. Almost all were complex in nature, and did not lend themselves to a tabular presentation as used in the other questions. However, we found that the consensus among interviewees was that the quality of technical reports has definitely improved over time, partly because the reviewers on MEND technical committees had themselves become more knowledgeable and critical, and also to some extent because of the current emphasis on a strategic research plan which was not present initially. Virtually all respondents considered recent reports to be at least "adequate", and sometimes "excellent" in quality. The thrust of the work carried out was seen as practical and useful, if not always at the level expected of publications in refereed scientific journals:

*"Good engineering science; very focused and specialized. But concise case histories are lacking. Need to have the 'bigger picture'."*

Some criticism was voiced that raw data were often published without sufficient analysis; but one respondent commented that this is often useful for later researchers to re-analyze and re-evaluate the original work. One comment is worth noting, as a caution to users of the reports:

*"In some cases bad science is being done using MEND outputs; these are instances of valid basic work not being well applied in practice. E.g., controversy over aging effects in waste rock piles. Some consultants just plain use out-dated practices, and maintain over-simplistic views."*

We also asked about how useful or comprehensive respondents found MEND's results on an economic or financial level. Most respondents (23 out of 38 who answered) considered the economic or financial data reported by MEND to be useful as a guide or tool to assist in estimating costs for specific sites. Some typical comments:

*"They are a good base to start from. They must be site specific – that is, to estimate costs for a specific project you can't just take a set figure of so many dollars per hectare for some specific type of treatment."*

*"...the costing information is too generic to be applied to specific sites. Companies still need to do their own costing."*

An additional ten respondents were generally approving of the effort to provide economic data on AMD treatment

*"Reasonably accurate work. It is useful for regulators to get an idea at least of the order of magnitude of costs involved."*

### **3.1.2 Associates Survey**

Here are some representative excerpts from respondents' answers to this issue:

*"Progress re prediction has been less than I would have guessed (predicted?) back when MEND was just getting started. Some progress has been made but I certainly do not believe that MEND has provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock."*

*"Definitive prediction for reactive tailings and waste rock is still a problem, but MEND has increased our understanding of the factors that can affect ARD and what can be done to limit ARD as a consequence."*

*"They have been very useful within a North American context in providing clear and comprehensive set of reported experiments and reviews. They*

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*need to now start to produce practical Codes of Practice that can be adopted within a legal framework."*

*"MEND has, over the years, provided current information via reports about prediction testing and modelling as well as techniques for waste management."*

*"MEND has provided good scientific and technological methodologies for prediction and early warning. However, as AMD is a long-term problem, the full benefits have not been seen in the project life."*

### **3.1.3 Conclusion to Issue 1**

Before the establishment of MEND, many people in both industry and government knew of the existence of acid mine drainage, but had no clear idea of how to solve the problem. Experiences at mine disposal sites were for the most part negative ones. MEND has produced a wide variety of useful knowledge and technology? essentially a toolbox of potential solutions. Among these are the use of water covers and dry covers for preventing AMD in both tailings and waste rock. A particularly important outcome has been the development of a common understanding among participants, inasmuch as it has allowed operators to take actions with greater confidence and to gain multi-stakeholder acceptance more quickly. Opportunities remain to establish definitive prediction methods, as well as to develop practical codes of practice which are acceptable within a legal framework.

## **3.2 Reduction of environmental impacts**

*Issue 2: What has been MEND's contribution to reducing the harmful impacts on the environment of acid mine drainage?*

### **3.2.1 Personal Interviews**

We first asked respondents if they could name any of MEND's projects or findings that have already helped to reduce harmful impacts on the environment. Among the 44 responses, 40 identified situations or ways in which MEND helped reduce harmful impacts on the environment; only four stated MEND had had no effect. Of the 40 positive responses, six stated that MEND's main contribution has been the development and promotion of the underwater disposal technology. In addition, a total of 17 individual sites were mentioned by individual respondents as examples of the application of MEND's results to the reduction of environmental impacts. The most frequent was the new Louvicourt mine (five mentions), Equity Silver (two mentions) and East West Caribou (two mentions). The other 14 sites each were named by one respondent. Other impacts of MEND's efforts, which are not necessarily related to specific sites, were referred to by ten respondents. A few typical comments:

*"MEND contribution has been substantial in promoting awareness, encouraging investigation and stimulating thinking."*

*"Knowledge has been disseminated through MEND, thus permitting fewer unexpected disasters than otherwise would have been the case."*

*"MEND has permitted a better evaluation of the options on mitigation and avoidance of AMD."*

*"Most companies using tailings ponds are managing them differently because of MEND's findings."*

When asked about potential reductions in harmful environmental impacts that have not yet happened but that perhaps might be attributable to MEND in the future, only 23 responses were received; two of these respondents knew of no potential reductions that would be ascribed to MEND. Among the 21 positive responses, six mentioned dry covers in general as being promising, and two referred to water covers. The Louvicourt mine was mentioned three times, and six other sites were also named. Four responses referred to the expectation that MEND would be responsible for environmental improvements in a general way.

### **3.2.2 Associates Survey**

The response to this question was extremely varied, ranging from "Poor", to "Advanced significantly". Some representative, "middle of the road" comments:

*"The control and treatment of ARD has advanced significantly due to the effects of MEND. Technically it is possible to effectively eliminate the harmful impacts, but the economics are not always acceptable."*

*"MEND has provided evidence of success and access to expertise which has encouraged all sides to commit to ARD prevention programs and capital works ? leading to considerable AMD reduction."*

*"I believe MEND's efforts in this area have been more fruitful, and have greatly contributed to the knowledge base of key practitioners, which in turn has improved overall water quality."*

### **3.2.3 Conclusion to Issue 2**

While, almost by definition, this question is impossible to answer in the short run, there are promising indications that MEND's efforts will help reduce harmful environmental impacts. We found a total of 17 individual sites where such impacts have already been ameliorated. In addition, MEND's work in the distribution of knowledge, stimulation of further technology developments, provision of examples of success, and improvement of general awareness both of the AMD problem and its potential solutions, are all expected to result in future reductions in harmful environmental impacts.

### **3.3 Cost reductions due to MEND**

*Issue 3: Have MEND's R&D products resulted in net reduced costs associated with*

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*opening new mines, operating and closing existing mines, and in rehabilitating abandoned mine sites?*

### **3.3.1 Personal Interviews**

In addressing this issue with respondents, we found that a few identified "products" not normally considered in the R&D context, such as conferences, videos, and MEND committee meetings themselves. One respondent neatly summed up the consensus of the others:

*"This MEND knowledge is a prerequisite for being in the mining business nowadays."*

We found significant variations in the responses we obtained to this issue. We separated the discussion into three segments: opening costs (including planning, design and permitting costs); operating and closing costs; and rehabilitation costs for abandoned or orphan sites.

Of the 39 responses received, four respondents didn't know whether net opening costs had been reduced. Among those who gave an opinion, 15 said opening costs had been decreased due to MEND. The following are some representative comments:

*"For new mines, the costs are definitely reduced because of the increased reliability of the prediction and costing steps, and prospectively reduced because of the better mutual understanding of the technologies by all parties (companies, consultants, regulators,...) By making full use of AMD prevention techniques, etc., and not exploiting certain ore bodies (eg, some small open pit operations), the costs can be an order of magnitude lower than for existing mines."*

*"Subaqueous disposal: can get quicker approval for plan, thus cutting planning and approval costs. Closure costs are also reduced because the companies can reduce the amount of bonds or get their bond back*

*sooner."*

A total of eight responses pointed out that the main effect of MEND had been to reduce the risk associated with mine design and permitting by increasing the knowledge about AMD. For example:

*"The better prediction methodology makes operators' liability more controllable, thus represents a reduction in risk level. MEND has provided reliable closure options, which are cheaper than running water treatment plants for hundreds of years."*

On the other hand, eight responses stated that opening costs had actually increased for a number of reasons, as shown in the following quotes:

*"Costs have increased, but the money is being better spent: the companies are not wasting their resources on re-inventing wheels."*

*"Actually, the front end costs are larger: e.g., for the [name on file] mine, they have already spent \$300,000 on ARD prediction and planning alone. Knowledge of ARD potential has influenced mine planning, resulted in reduced size of mine."*

*"The level of testing now required increases the costs, but it has also increased confidence."*

*"Increased costs, due to the testing procedures now required."*

One respondent commented that one mine would not have been opened at all had it not been for the information available through MEND.

With respect to operating and closing costs, 42 responses were received (only one of which



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was "don't know"). Of the opinions expressed, 19 were that operating and closing costs had decreased. The following comments are representative:

*"Costs of operating can be reduced: most new mines should be able to reduce costs by about 50%. Costs of closing can be reduced astronomically. Eg. The actual costs of closing the [name on file] site were about \$100 million. If they had had MEND knowledge initially, and had designed based on it, ideally it could have been closed for about \$5 million."*

*"For existing and closed mines, the costs are higher than those dreamed of a decade ago (ignorance and wishful thinking), but less in specific cases where the new technologies can be effectively applied (e.g., in-pit disposal). A reasonable estimate is that reliable and adequate closure of existing and closed mines can now be achieved for about 10% less than ten years ago, and that further incremental savings are possible."*

Again, ten of the responses indicated that a major benefit was the increased confidence, and decreased risk, resulting from increased knowledge; for example:

*"Improved knowledge can give increased confidence; but can result in increased costs due to 'doing it right'."*

*"MEND helps identify what will and what won't work. Again, costs of operating and closing will depend on the situation, may be higher or lower than they would have been without MEND, but will be realistic and more trustworthy."*

As in the case of opening costs, there were some contrary opinions expressed: six said operating costs had increased, and another six said there had been no change in costs. Some quotes:

*"Operating costs: may be higher. Closing costs: probably lower. Bonds posted may well be higher."*

*"Treatments are more costly, since operators are having to play 'catch up ball' to treat existing badly-designed sites."*

As for rehabilitating abandoned sites, 34 responses were received, of which two said they didn't know if costs would have changed due to MEND. Nine respondents said that no change had occurred, and five of these suggested that budget restraints were the main reason. For example:

*"No: because orphan sites are Crown-owned and the Crown has no budget to do this."*

*"Re orphan sites: Decommissioning costs in Ontario are estimated at \$150 million, and there is no budget to do this. For example in the [name on file] mine, can only afford to do studies on how much the work would cost..."*

The other reason advanced to explain a lack of reduction in costs for rehabilitating closed sites was that such savings are not always physically possible:

*"In certain circumstances; e.g., where one can backfill the waste into the hole and flood it. But for conventional sites, the answer is NO: the opportunity is just not there."*

On the other hand, five respondents thought that rehabilitation costs would be decreased because of MEND. Some representative quotes:

*"Costs will definitely be lower because of MEND, irrespective of the ownership of or responsibility for closed mine sites. There are literally*

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*thousands of such sites across Canada, but their impacts are mostly minuscule compared to those of modern mines."*

*"The knowledge available to assist in the planning process will permit savings on consulting costs...."*

An interesting point was made by four respondents: it is a good idea to be cautious in spending money on rehabilitation, and on occasion it might even be better *not* to attempt mitigation at all (although the respondents' perceptions of MEND's actual role in bringing this message seemed to vary considerably):

*"...MEND has helped through teaching us how to assess the situation, and to decide what actually needs to be done. For example, if all rock is found to have oxidized already, there is no need to mitigate since no further trouble should occur."*

*"...Also MEND has shown that it is sometimes best to let sleeping dogs lie: e.g., near [name on file] an old tailings pile had healed itself over a period of 60-70 years. It was opened up again, to provide material for fill ? and it started to "cook" all over again."*

*"Costs of rehabilitating abandoned sites will depend on the situation, may be higher or lower than they would have been without MEND, but will be realistic and more trustworthy....One critical omission in MEND's effort has been to look critically at what needs to be done, not just at what can be done. Example: the railroad beds leading to [name on file] are made of acid rock taken from the [name on file]. They are generating acid (it keeps down the weed growth around the tracks) but it filters through the underlying soil and is not detectable in the surrounding watercourses. Moral of the story: sometimes one need not, and should not, disturb an existing situation."*

*"We're not doing as well as we could. A lot of money is being wasted trying to fix up orphan sites."*

Finally, three of the responses indicated that there was no problem with AMD at abandoned sites in their regions.

A further discussion of MEND's impact on mine opening, operating and closing costs is given in section 4.1 of this report, *"Are Costs Really Lower Because of MEND?"*

### **3.3.2 Conclusion to Issue 3**

MEND appears to have been successful in helping to reduce opening, operating and closing costs, at least in some instances, because of the increased confidence and reduced risk associated with the design and permitting phases. For five cases where respondents provided estimates of cost savings due to MEND's work, the total amounted to approximately \$340 million. However, in some cases, costs may have been increased due to the improved knowledge MEND has provided about the real potential for AMD generation which otherwise might have gone unsuspected. MEND does not appear to have contributed as yet to cost reductions in the rehabilitation of abandoned or orphan sites, probably because relatively little is being spent on such efforts.

## **3.4 MEND's impact on the regulatory process**

*Issue 4: In what manner and to what extent has MEND contributed to setting more realistic regulatory requirements, and to making the regulatory process less complex and more efficient?*

### **3.4.1 Personal Interviews**

Only 22 respondents answered the question of whether MEND has contributed to governments

setting more realistic regulatory requirements for the handling of reactive mine tailings and waste rock. In the view of 14 of the interviewees, MEND has had a significant impact upon the regulatory process in two distinct ways:

First, MEND has improved the understanding of potential AMD hazards, among regulators, mine operators, consultants, and intervenors in public hearings. All these stakeholders have had the same opportunity to acquire information held in common. The information has been widely shared so that all are now "playing on the same field". The operators know what questions the regulators will ask, the regulators know what sort of answers will be forthcoming from proponents, and the intervenors have a better understanding of the scientific basis and validity of what they hear. A few typical responses:

*"More along the line of confidence-building on the part of regulatory boards."*

*"Yes; companies can now bring better information and analysis re predictions. Government can now use more science and not just emotion."*

Second, the relationship between mine operators and regulators is more cooperative and less confrontational. The whole acid mine drainage situation is now viewed as "our" problem, not "mine" or "yours". There is a synergy generated by all stakeholders working in relative harmony to try to solve a common challenge. The result is that less time and effort is spent in confrontation, and more is devoted to addressing the problem of AMD, and finding workable solutions in specific cases. Again, some representative quotes:

*"Regulators have changed attitudes. Everyone has become better equipped to understand, both regulators and industry."*

*"There is more of a change in attitude. The regulations themselves are structured to be flexible, and it is up to the regulators to use their own*

*good judgement."*

There is, however, a "down" side to the situation: we discovered that some regulators in two environment departments (the federal and one province) feel somewhat left out of the relationship. These stakeholders have been aware that they are relatively uninformed about MEND and its results, but they seem to have done (or have been able to do) little or nothing to correct the situation. Some of their comments (often in responses to other questions) are:

*"...can't answer the question because they don't know what MEND's results are." "There should be more sharing of the information produced." "The respondents don't feel they are included, and they would like to be." "They would like to get into the loop for information."*

*"They don't see a large flow of information coming out of MEND. It is difficult to obtain the information. MEND participants should take more of a proactive role in spreading the word around."*

At the same time, six of the 22 respondents indicated that there had been no change at all in either regulatory requirements or in the process itself, and two said that MEND had had no impact on any changes that might have occurred. For example:

*"Under the Fisheries Act, the respondents are responsible for regulating mining effluent discharges. They see no impact of MEND on this matter."*

Respondents were careful to distinguish between MEND's possible impacts on the regulatory process, and impacts on the wording of regulations themselves. Of 27 interviewees who responded to the question, "To what extent have changes in regulations been attributable to MEND's existence?", ten replied that MEND had had no influence on the regulations. One interviewee elaborated on this answer with the significant comment:

*"There has to be a clean boundary between the research process and the*

*regulatory revision process. The two are not the same."*

A total of eight respondents pointed out that MEND has influenced the formulation of policy, and eight more indicated MEND's influence on the regulatory process:

*"Policies and guidelines have been affected by MEND. Example: ARD Guidelines for Mine Sites in British Columbia, by William A. Price and John C. Errington (Jan. 1995)."*

*"MEND outputs probably influenced the Sulphide-Bearing Materials Regulations under the Nova Scotia Environment Act, dating from about 1995."*

*"No change in regulations, but the **process** has been facilitated."*

*"MEND has helped regulators to understand that the rules can't be based just on numbers: they must also consider the risks involved and decide what is feasible."*

When asked about MEND's possible impacts on the complexity of the regulatory process, 30 respondents expressed opinions. Of these, 14 stated that, in fact, the increased knowledge due to MEND had actually increased the complexity of the regulatory process:

*"With better education about the problem, the process has become more complex."*

*"The more you know, the more complex it gets. But MEND's outputs make it possible to manage the complexity."*

Contrariwise, seven respondents felt the process had become simpler:

*"The regulatory process is better understood now in part thanks to MEND. It has improved the level of communication and understanding between parties."*

A further seven interviewees said there had been no change in the process attributable to MEND. A few sample remarks:

*"He has not observed any impact of MEND on the ease or speed of the regulatory process: the shared knowledge has made the regulators' questions more probing and simultaneously made the operators' answers more knowledgeable, thus giving no net effect."*

*"MEND is not responsible for such changes at all."*

*"It is impossible to say, because the procedures have been changed irrespective of MEND and attribution is therefore impossible."*

#### **3.4.2 Conclusions for Issue 4**

MEND has not had any direct effect upon the wording of regulations, but the knowledge and understanding it has produced have been incorporated into policy in at least two provinces. Its major and very significant impact has been in providing this information to all stakeholders, including operators, regulators and consulting engineers, and thereby reducing uncertainties and increasing confidence among all concerned; and by facilitating an improved relationship between operators and regulators so that now the behavioural norm is cooperation rather than confrontation. The complexity of the regulatory process has increased to some extent because of the increased and more sophisticated knowledge provided by MEND, but this knowledge has at the same time made it possible to manage the complexity.

#### **3.5 Lessons learned from the MEND experience**



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*Issue 5: Has the design and delivery of MEND influenced its performance? What are the lessons learned?*

### **3.5.1 Personal Interviews**

Virtually all respondents agreed that MEND's structure and *modus operandi* have resulted in a tremendous synergism, as stakeholders with very different priorities and agendas came together to address a common problem and to work together to find practical and realistic solutions. Several of the respondents commented very favourably on the good level of participation that MEND had engendered among the various stakeholders. Some examples follow:

*"The selection and general definition of projects is quite good. It is via an iterative and broadly based review process involving a large number of supportive and involved people (mainly volunteers) with different backgrounds, perspectives and levels of experience. The essential elements are an agreed plan to tackle a priority problem which benefits from joint action. The mechanism is not critical; the general structure of MEND can be adapted to other situations, e.g., with more or less emphasis on the roles of committees, and different funding strategies."*

*"MEND has produced a better dialogue, and a more sophisticated approach on both sides: both government and industry are more educated in the technology of AMD, and they now speak the same language."*

*"Demonstration that adversarial and controversial issues can be addressed on the basis of a common understanding."*

*"MEND has been a good process, focusing on the issues and on understanding them. It has broken down barriers and allowed everyone to strengthen their own programs."*

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The question of MEND's influence on those who have not participated in its activities, however, elicited varying answers from the interviewees (who were all MEND participants). Of the 44 responses received, 14 stated that it is up to non-participants to seek out the benefits for themselves: the data generated by MEND are in the public domain, and are available to all who wish to buy the reports.

*"They should be able to get the information, since it is available: it's up to them to take the initiative."*

On the other hand, eight responses manifested some concern about whether the juniors, the other provinces, or the consulting engineering community were acquiring the knowledge they needed from MEND:

*"Consultants: excluded from committees. Feels this was a mistake: they could have helped advance things more, e.g., in the waste rock area which has been a failure. Provinces: BC was not involved enough, e.g., in the case of waste rock, but doesn't know why not. Juniors: trying to explore and sell properties rather than operate mines."*

*"Consultants were not participants; this could have been arranged while still avoiding conflicts of interest. The juniors don't know what is going on; they are frustrated with the regulators. The regulators don't hand-hold the juniors very much because of their lack of time."*

And six respondents said they thought the provincial and federal regulators should be acting as policemen, enforcing the knowledge and use of MEND data as appropriate:

*"Example drawn from an Alberta case (a program patterned after MEND and set up to address a problem in the coal and petroleum industry). The same setup was used, with the same results for participants. In this case, it was the regulators who brought the junior petroleum companies into*

*line."*

*"It behooves the regulators to ensure that problems are addressed up front. Small operators can cause damage out of all proportion to their size."*

*"The information is public. Non-participants could be less aware of the problems and of the solutions. He hopes the regulators will catch them up and make them more aware."*

As a general comment, ten of the respondents indicated that they thought all those in the mining sector would benefit, whether or not they participate in MEND, while five felt that those outside the MEND circle would not gain any benefit from its activities.

*"The juniors come and go; and anyway historically the problems are due to the majors. The juniors rely heavily on consultants (of which some are good and some are not so good). The consultants have picked up on the MEND information, since they have done most of the research project work."*

*"There are no benefits to them. Even within a given province, some regions are "outsiders". Also the cost of the documents can be a problem."*

A large number of comments and suggestions was received about MEND's organization and ways to improve it. (Earlier during each of the personal interviews, nearly everyone had heaped praise on MEND, so it is perhaps understandable that many of the interviewees took the opportunity to balance their reactions by offering criticisms and blunt suggestions for improvements.) In all, 48 respondents provided a total of 53 comments, of which only a few are quoted in the paragraphs below.

Although five respondents felt that MEND had had good participation from those who took part in the program, 13 of the respondents said that MEND should have invited other participants (consultants, mining companies, environmental bureaucrats and activists) to take part as well.

*"The MEND process is a good example of a multi-stakeholder approach to an R&D problem. The shift in emphasis after the first few years was a valuable lesson: the participants' commitment to a strategic plan was essential."*

*"MEND has been a very focused program. The collaboration has worked. The leadership has been excellent from both industry and the federal side. But more provincial participation would have been nice."*

*"Would have been good to involve the junior companies and consultants, but this would be an idealistic attitude: they don't have either the time or the financial resources to participate."*

*"On second thought, would have been better to bring in consulting engineers right from the start, as part of MEND. Also might have done well to involve academics as well."*

Eleven respondents said that the MEND committee structure was too complex and top-heavy, and eight felt the budget had taken too large a share of the committees' attention.

*"MEND has been overly structured, with too many committees, and too preoccupied with budgets. It should be driven by research goals instead: what needs to be done? This is partly the reason why many are feeling tired of it."*

*"MEND has reorganized itself several times, trying to improve its*

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*operation. There has been too much time spent dividing up the budget and politicking over acceptance of proposed projects. This has led to a major distortion of the research effort and a duplication of work at different sites, whose only reason was that they were different. There was not enough scrutiny of project proposals."*

Five respondents criticized various features of the project management that had been part of the MEND research projects:

*"One difficult area for consultants working on MEND projects: presence of some project managers who are not knowledgeable in project management. There is in fact a problem in project management generally: a lack of timely and effective response from the various players involved."*

*"The main weaknesses in MEND are related to the project management process:*

*(1) individual project definitions. Take too long to prepare due to a committee approach. Sometimes too loose or vague and/or inflexible re deliverables and schedules and penalties. Sometimes misinterpreted or ignored by contractors and reviewers. It is too late to do much about this as most projects are underway or complete. However, a clear definition of expectations is an essential yardstick.*

*(2) contractor selection. There may be a tendency to stand back and either pay to educate the contractor, or overload a few knowledgeable ones. The project managers must be good, and probably should be willing to get more involved in the project execution, to help contractors who are likely to yield a good product, but have less specific experience.*

*(3) project management re quality and timing. Many projects are late.*

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*Progress monitoring and draft report reviews by MEND staff and committees are sometimes ineffective or laborious. Again, the scope needs to be well spelled out, and consistently followed unless modifications are mutually agreed. The manager has to manage, and that includes making sure that reviewers do their jobs promptly and properly also.*

*(4) distribution of information. The information is not distributed widely in a timely manner. Improvement here relates to more emphasis on newsletters, workshops, report review/publishing expedition. The info is useless if not distributed and used.*

A further five respondents had other criticisms or comments to make, including some on regional problems:

*"Regional differences have caused some difficulties in assigning priorities: e.g., waste rock is a problem in the West but not so much in Québec. Would like to have written criteria for project evaluation. Would also like more timely response during the project evaluation process: have waited up to a year for an answer at times. There are too many part-time volunteers."*

*"...provincial preoccupations has resulted in the location of a test being seen as more important than the test itself."*

### **3.5.2 Associates Survey**

Almost all respondents lauded the openness, cooperation and collaboration between stakeholders which developed through MEND. None of the associates offered any suggestions for improvements to MEND. Two favourable comments:

*"I was impressed by the rapport between the Canadian mining industry*

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*and Canadian regulators in trying to solve the multitude of problems inherent to ARD."*

*"Much can be done when many work to attain a common goal."*

### **3.5.3 Conclusion for Issue 5**

MEND serves as a strong internationally-recognized model of government-industry cooperation. The organizational structure and collaborative nature of the initiatives received unparalleled (in our experience) praise in this regard. Future opportunities exist to streamline MEND and to improve both its project management system and its outreach to non-participants, building on its record of collaboration to ensure continued positive, practically-focused work.

## **3.6 Technology transfer**

*Issue 6: To what extent have the technology transfer activities of MEND succeeded in informing the target audiences about the issues of acidic drainage and about the technologies which can deal with the problem? To what extent is decision-making on acid mine drainage now based more on science and technology considerations as a result of MEND?*

### **3.6.1 Personal Interviews**

We found that respondents were mostly well aware of the various MEND technology transfer activities. They mentioned:

- international conferences;
- local conferences;

- workshops;
- technical publications;
- the forum provided by the technical committee meetings;
- the Internet home page;
- videos;
- MEND newsletter; and,
- MEND annual report.

Respondents generally agreed that the target audiences for these activities variously include industry, consultants, government regulators and policy makers, university researchers, environmental interest groups, schools and the general public. Several mentioned that the videos are especially aimed at students and the public.

Of the 46 respondents to this issue, 20 thought that MEND is indeed reaching its target audiences. However, a further 19 interviewees commented, "It could do more". Only three said that MEND was not reaching the appropriate or target audiences for its technology transfer "products". The following lengthy and thoughtful comments indicate the degree of interest and concern for future success shown by the respondents:

*"In general, most of the target audiences are being reached to some degree via participation in MEND and in the Workshops.*

***Technical reports and manuals:** the "sales" are well below the "market", despite current publicity of what's available. If the objective is to have the info used, it is better to give away 1,000 copies to the potential*



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*users, rather than to sell 100. Also the info may be years late getting out due to contractor delays plus the delays in the review and publishing process. Fix the delays and also publish frequent "Preview Abstracts" as well as news letters.*

**Newsletters and "Preview Abstracts":** *Newsletters should be frequent and informative and timely. In addition, short technical abstracts should be issued to provide key info in a timely manner.*

**Workshops:** *Should have presentations, panels, case studies and brainstorming. Some are being done across Canada on different topics to end 1996. These approaches should be expanded, extended and improved.*

**Videos:** *are a tool, not an end in themselves. How can they be employed?"*

*"The workshops, reports, conferences were all excellent and have reached their audiences. But MEND needs to have an encyclopedic indexed report or review on each area of technology (such as prediction, closure, wet covers, etc.) This should be designed for use by the educated public as well as by mine engineers."*

*"Workshops need advertising, but how? is the question. MEND is missing out with the smaller companies."*

*"It could do better. For example, we need an intermediate level of report, somewhere between the 2-paragraph abstract and the 100-page report: maybe a 10-pager. The reports are not known widely enough. The price of \$25 per copy represents an effort, an impediment, rather than a hurdle. There is a need to distil the results into a practical guide for field work."*

*"No, although new communications techniques are being tried. The workshops are excellent and helpful: they must have the right time, place and subject to work well. Recently they have been based on recent project results, when the project report is still at the draft stage. The workshop then serves as a two-way conduit for information and constructive criticism. They are well-advertised ahead of time. They also serve as "carrots" to attract potential responders to forth-coming RFPs for follow-on work, as well as a useful pre-filter to screen out would-be researchers who would not likely be acceptable performers."*

When we asked respondents in the personal interviews the second part of this issue ? "Do you think that decisions in this area are based more on science and technology considerations as a result of MEND's activities?" ? we were able to get answers from only 13 interviewees. Of these, four said that science and technology is playing a larger role in decision-making due to MEND, two said no, it is not, and six said this is partly the case. The following excerpts indicate the variance of opinion:

*"Yes: the regulators are partners in MEND. However, environment departments are noticeably missing frequently at the MEND discussion table."*

*"Yes: MEND information can help support decisions even though lobbying may be strong. Most decisions are based on social arguments, but scientific information can back up the engineering plans."*

*"No. Decisions are still based on sociological, lobbying inputs."*

*"Operating permits are being negotiated on a more objective and factual basis because of the availability of a common pool of good information, but this will require a continuing education effort. Also there is increasing*

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*need to involve groups such as natives and environmentalists, while recognizing that they may not be much influenced by MEND's specific concern of science and technology."*

*"...the [company name] mine hearings in the NWT are based 70 - 80% on socio-psychological considerations. Nothing in human activity is totally logical or science-based."*

### **3.6.2 Survey of Junior Mining Companies**

Our independent analysis of the extent to which the operators of potential AMD sites have been reached by MEND's technology transfer efforts showed that indeed MEND appears to be covering the vast majority of organizations having a significant AMD risk. As described in section 2.3 of this evaluation report, of an estimated total number of over 100 active mine sites identified as having a significant risk of AMD generation, we found that 30 juniors were indeed potential "clients" of MEND. Of the 16 we were able to contact and interview by telephone, only four were unaware of the existence of MEND. Of these four, three said they had no AMD problem at sites for which they were responsible. Only one junior company had never heard of MEND, had an AMD problem (at least one of six abandoned mine sites), and wanted to find out more. (This company's name has been passed to the MEND Secretariat.)

### **3.6.3 Distribution of MEND Reports**

In addition to the Personal Interviews and the survey of junior mining companies, we attempted to obtain and analyze data on the distribution of information to *non-partners* of MEND. Included in this group would be the junior mining companies, provincial government departments which do not sit on MEND committees, and consultants which have not participated in MEND projects.

Reviewing the results of our interviews, as described above in section 3.5.1, we found that some MEND partners take the approach that the technical information is public and accessible

to all who want it: it is the responsibility of the non-participants to obtain it however they can. We also found that most, if not all, the non-participant mining companies normally hire consultants to carry out their design and planning, and that the consultants were expected to know about MEND results. And finally, some MEND participants told us that they consider it the regulators' job to "keep mine proponents in line" and to make sure that the knowledge MEND has produced is used in appropriate ways to ensure correct handling of the AMD problem.

On the other hand, a few non-participants (two juniors and five environment department officials) told us that they find it difficult to find out what is available in the form of MEND reports. Also, it was suggested to us that some consultants are not as competent as others, and may not be as aware of MEND information as they should be. Some regulators from provincial environment departments do not share in any MEND activities and may find it difficult to find out or access the information they should know about. And finally, a few respondents told us that MEND reports were too expensive, and one or two thought they should be free. We decided to see if these criticisms could be confirmed by analyzing sales data.

Since April 1, 1996, MEND reports have been sold through the Secretariat. To mid-June of 1996, 85 copies of various reports had been sold.

During the two previous fiscal years (94-95 and 95-96) sales were the responsibility of the CANMET library. They recorded sales of 35 and 193 copies for these years, respectively.

Prior to April 1, 1994, the distribution of these reports was handled by CANMET's document distribution office. As a result of the disappearance of this office during a departmental reorganization, detailed sales data are not available for earlier years. However, using a weighted mean for the average price of documents sold, and an educated guess (by the ex-manager of the document office) at the total value of sales over the period, we were able to estimate that a total of perhaps 315 copies of MEND reports were sold during this time.

The combined total of recorded and estimated sales of MEND reports is thus 628 copies.

What are the market characteristics of these report sales? Did all reports have sales? Did any have no sales? Were there large quantities sold or only a few reports ?

There are 72 different reports listed as available in 1996. During the past three fiscal years (the only ones for which data are available) 53 reports have had sales; the remaining 19 reports have not been sold during this period. A total of 36 reports sold during more than one fiscal year. The maximum number of copies of any report sold is 13, which does not seem to be an unduly large number. There were two reports which sold 13 copies, three which sold 12 copies, three which sold 11, three which sold 10, and four which sold 9 copies. All these sales spanned at least two and usually three of the fiscal years for which data are available. These 15 "best-sellers" published by MEND account for more than half of the copies sold during this period.

The total revenue from sales to date is nearly \$20,000 (\$9,700 since 94-95 and an estimated \$10,000 in previous years), at a weighted average price of about \$31 each.

Without a more detailed analysis of the buyers for these reports it is impossible to come to a definite conclusion, but it does appear that MEND's technical reports may well be reaching a significant number of users.

#### **3.6.4 Conclusion for Issue 6**

MEND has successfully reached its target audiences in the mining field with the efforts it has developed to date. The workshops MEND presents have been particularly successful: a comparison of the level of satisfaction of their participants with a standard benchmark, established for 20 Canadian technology centres, showed that MEND workshops scored higher than average. Decision making on acid mine drainage is, at least to some extent, based more on scientific considerations, but sociological inputs probably remain pre-eminent. Future opportunities exist to more fully develop technology transfer products and services, and to

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ensure that all stakeholders, including non-operators such as environmental regulators, are fully informed about MEND's activities and outputs.

### **3.7 Mining's image and credibility**

*Issue 7: Has MEND influenced the image and credibility of the mining industry regarding protection of the environment? In what manner and to what extent has MEND contributed to enhancing Canadian leadership internationally in the science and technology of the prevention of acid mine drainage?*

#### **3.7.1 Personal Interviews**

We asked interviewees if they felt MEND had influenced the image or credibility of the mining industry among politicians, environmental interest groups, or the general public. Of the 43 respondents who answered, 22 said no, MEND had *not* influenced these groups. A further 17 said that MEND had "partly" influenced them, and one respondent said "yes" with no further comment. Some representative comments follow:

*"Any change in image is due to the companies' efforts, not to MEND. Some NGOs have become knowledgeable: some in fact are now ignoring the mining sector since they feel it no longer needs or merits their attention."*

*"Among the public: no. Environmental activists: they see only what they want to see. Politicians: no. First Nations: they are more business-like than the general public."*

*"There is no impact on these groups. Environmentalists regard this as "science" which they don't appreciate ? they have their own agendas."*

*"Would like to say "yes", but there is no evidence to support such an answer."*

*"Some people have preconceived notions that mines are bad; you can't reach them. However, MEND can affect open-minded people."*

*"Not to date: MEND has not been a public relations exercise."*

*"Mining companies are usually viewed as slightly above lawyers and used car salesmen. In general, they deserve that bad image. The major companies are now sincerely trying to do right; hopefully, good public relations will come by itself."*

*"Environmentalists have had positive experience in MEND workshops [respondent thinks this aim has been one of MEND's goals]. There has not been a whit of impact on the general public. Among the environmental community, MEND has generally not been perceived as a public relations exercise. However, the presentations by MEND at the Elliot Lake FEARO hearing did introduce some scepticism among the five "public" groups present (three environmental groups, one labour organization, and one representative of the First Nations). This was because only one option was apparently being touted as feasible, and the groups felt it sounded more like a sales job than a scientific presentation."*

*"MEND has not reached the general public, which is not very interested anyway. Environmental activists sometimes don't want to know, particularly the internationally-based ones which are more interested in fund-raising than finding cures to problems. However, some of the local associations are more interested in real solutions and do want to know about them (e.g., the Comox Valley Watershed Assembly)."*

When we asked if Canada is perceived as a leader among other nations in the field, 44 respondents replied. Aside from three who didn't know, an overwhelming majority (40 interviewees) gave an affirmative answer. Some typical comments:

*"We have a high profile and are considered the leader in the English-speaking world."*

*"Canada's leadership is recognized by objective observers. The US is jealous of Canada's stature; they have ignored problems in their own base metal industry. The Australians and Norwegians think we're OK, the Swedes are pretty closed-minded and don't recognize anyone else's ability."*

*"Canada's leadership in the field of AMD prevention comes from the importance we give to the resolution of this problem. This is all to the good, but we must not forget that other industrialized countries also are taking measures to counteract AMD."*

*"Yes, we are leaders. And are seen as such all over the world."*

*"Canada ranks with the U.S. as world leaders. Some companies such as Inco and Falconbridge have good reputations internationally, and this reflects on Canada."*

The one respondent who said Canada has a bad international image answered as follows:

*"Canada's image is bad in the US among the public and the environmental community. However US industry sees us as being enlightened."*

We asked about MEND's contribution to Canada's high standing, and received 48 replies



(including one who didn't know). Of the remaining 47, 45 confirmed that MEND has contributed to Canada's reputation in the field. Of those who identified specific ways, 17 cited the international conferences sponsored by MEND, five credited the activities of the MEND Secretariat, a further five noted the international work of the consulting engineering community, and two cited the dissemination of technical information produced by MEND. The following are examples of the many glowing comments received from respondents:

*"Yes: our reputation is due to programs like MEND. It has helped through the media of handbooks, documents and conferences. This contractor has not gained new business through MEND, however: in fact, they now face increased competition from other Canadian firms because of the knowledge gained through MEND."*

*"MEND has improved the credibility of the mining industry with many government, research and university groups, based on good science and engineering, including many such groups outside Canada. This we can and should build on."*

*"MEND has brought Canadian leadership to the foreground through participation in international conferences, and the international diffusion of information. Grant Feasby in particular has been involved in advising on many international panels, etc."*

*"...simply the description of MEND is a powerful selling tool, demonstrating Canada's leadership in the field."*

*"Our reputation is due chiefly to MEND, and its international liaison activities. We have shown we are ahead of the pack. MEND hasn't missed any great opportunities to make ourselves known."*

*"MEND has helped our reputation by focusing on good projects. The*

*large conferences are the best way to promulgate the information."*

### **3.7.2 Associates Survey**

Most respondents replied that MEND has enhanced both Canada's reputation, and that of the Canadian mining industry, particularly in the international arena. Some typical comments:

*"Through their work Canada has become the leader in R&D in the more physical-chemical processes in the field of AMD and ARD."*

*"...it would be safe to say that Canadian industry is leading the way in this area."*

*"MEND has demonstrated Canadian expertise internationally, and provided a global clearing house for information, and a benchmark against which other countries can be measured."*

But a cautionary note was also sounded by one respondent:

*"I think that MEND has improved the industry's image regarding environmental protection, but probably only to itself and government. Public information and public consultation was very limited."*

### **3.7.3 Conclusion for Issue 7**

MEND has not attempted to exercise a public relations function, and perhaps as a result, has not influenced the general public's opinion of the mining industry to any significant extent. It has had a small positive effect upon some environmental groups, which however seem to retain a sceptical attitude toward the mining industry. On the other hand, MEND is credited for having considerably enhanced Canada's international reputation in this area, particularly because of the example it has set of commitment to solving the AMD problem and of cooperation among

stakeholders. Opportunities still exist to improve the industry's image in the eyes of outsiders, but this perhaps should be left to the companies rather than to MEND.

### **3.8 Recommended focus until 1997**

*Issue 8: What should be MEND's focus until its anticipated completion in 1997?*

#### **3.8.1 Personal Interviews**

Most respondents to this question gave more than one suggestion; a total of 78 items were mentioned. In order of importance, the recommendations were: finish up project work that is already underway (30 respondents); finish compilation and publication of the MEND Manual (19); concentrate on technology transfer activities, to ensure maximum dissemination of the results as they are available (15); plan for future work, including whatever is decided on as a continuation of MEND (7); evaluate the work that has been done, to enable future work to build on a solid foundation (4); and complete the organization and staging of the Vancouver conference in 1997 (3). Typical comments were:

*"Finish up the loose ends, including the Manual."*

*"Document results to date, finish the targets already set. Summarize, make recommendations, document both successful and unsuccessful cases, publish guidelines."*

*"Make sure all information is distributed. Review the Technology Transfer activities."*

*"Finish off, particularly generic things. Monitoring Manual, in particular."*

*"Tidying up, documenting reports. Complete the MEND Manual. Run the*

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*1997 Vancouver conference. Technical committees should wrap up a status report on work still needing to be done."*

*"Close off as many projects as can be done: in particular, ones that will give practical tools to operators and regulators. He wants to see a protocol or "cook book" on how to test materials and design covers, for example, based on general principles and techniques, not on site specific situations."*

*"MEND Manual is vital. Needs to have a good index, could be a searchable database format. Should be aimed at the preliminary design level, with a general treatment of issues."*

*"Finish the MEND Manual: should be similar to the old Pit Slope Manual published by the EMR Mines Branch. Needs a major chapter on each section of MEND. Not necessarily to be updated regularly, but should be a complete "snapshot" of current state of knowledge."*

A total of 16 interviewees identified reasons for considering these priorities important. The reason most often given (eight respondents) was the feeling that it would be wise to conserve the momentum already generated, and not to waste the work that had already been done. Two others indicated that the focus they suggested was of economic importance either to their company, to the mining industry, or to the country. Six respondents gave other reasons. Some representative comments:

*"Don't want to lose the experiential results. Should glean all possible information from the projects. Experience is of use in the US in formation of the Acid Drainage Technology Initiative, which is patterned after MEND."*

*"Decommissioning costs are a big expense for mining companies. Sludge*

*disposition and water covers are important issues for them. The economics are very important."*

*"To do otherwise would be to waste the past effort."*

*"At this point some momentum exists; there is a risk of losing it."*

*"Needs to be produced while the information is still current and fresh."*

*"They have just started to get it right: they have learned how to do incremental research, rather than forever engaging in a search for the magic solution to the AMD problem."*

### **3.8.2 Associates Survey**

The Associates focused on two main thrusts: technology transfer, to ensure that MEND's results are made available to all stakeholders; and planning and preparation for ongoing, continuing work on further research. Typical responses:

*"Technology transfer and concise synthesis of all that has occurred. All of the good research, new initiatives and findings must be made available to the industry, government regulators and mining consultants so that they can be applied."*

*"Forming a lasting network of researchers to ensure its focused research continues in a coordinated manner."*

*"Given the limited time, completion of ongoing work and technology transfer is all that MEND can focus on."*

*"Pursue its effort in the application of new technologies and technology*

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*transfer."*

### **3.8.3 Conclusion for Issue 8**

The three top priorities identified through our consultations with stakeholders were:

- to finish up current projects and outstanding work and to plan for future efforts, so as not to lose the impetus and momentum that has been generated over the past years;
- to complete and publish an integrated manual covering the entire range of acid mine drainage topics, so as to provide a practical and useful code or handbook of knowledge and practices for acceptable mine design and operation; and
- to continue and extend the existing technology transfer initiatives.

## **3.9 The next step**

*Issue 9: Is there unfinished business or changing circumstances that would suggest a need for future phases of MEND beyond 1997? If so, how should MEND be constructed and delivered, and what are the cost implications?*

### **3.9.1 Personal Interviews**

We opened discussion of this issue by asking respondents if MEND had now addressed all the important questions associated with AMD. Of the 29 interviewees who answered, ten said they thought the important problems had indeed been looked at, while 16 said they felt there were still major issues to be investigated. Some typical responses:

*"MEND hasn't got into the mining process deeply enough, far enough upstream. It should have investigated for example the selective handling of waste rock and tailings ? i.e., the avoidance of the problem through*

*smarter handling of the materials. Also MEND hasn't done much in the area of really long-term treatment."*

*"Some have not been touched on, but they are so costly or site-specific that MEND is really not the way to address them (e.g., some biological considerations)."*

*"All important problems have been identified and looked at. All solutions maybe not found."*

*"MEND has looked at a broad spectrum of issues. But it has completely ignored the submarine environment, due to the federal government not wanting to include salt water under the term "aqueous"."*

*"Doesn't know for sure. But the lime treatment process worries him: it isn't the perfect answer. What to do with the sludge produced? There needs to be a better process."*

A total of 39 respondents identified a wide range of topics which they considered should be investigated through future work. These potential subjects for further research (in no particular order) include:

- biological effects and methods of treatment;
- long-term behaviour of covers, and ramifications of long-term treatment;
- prediction modelling;
- prevention and avoidance of AMD;
- disposal of sludge;

- the effects of permafrost on AMD and its treatment; and,
- the continued up-dating of documentation of the completed work.

A few representative responses are:

*"Yes: biological effects still not known. Marine disposal is just starting to be considered. If there is a "Son of MEND", must include biological observations as part of the R&D projects."*

*"There are still a lot of mines ? hundreds in Ontario alone ? including abandoned sites, which still need to be looked at and remediated. Maybe would not involve a whole lot of research."*

*"Waste rock is a major problem since we can't get representative samples. The pieces of rock are individually variable. There is a question whether it is even possible to fully specify the problem or understand the process in generic terms."*

When asked if changed circumstances indicate a need for a continued MEND program, 22 respondents answered. Of these, 14 said MEND should continue, with two others recommending a break in the action to decide what to do next, while the remaining six respondents felt it should be terminated. The following representative comments give an idea of the thinking behind the responses:

*"There is a need for a continuation of MEND: AMD problems still exist, even though governments have cut back funding."*

*"Should continue, do more basic research."*



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*"Need long term monitoring network. For example, [in the] [name on file] area ... after 15 years, a waste rock pile suddenly began to ferment, probably due to catalysis by thiobacilli."*

*"MEND needs to be terminated on schedule. There should be a break for rest and reflection."*

*"Original objective has been reached: to reduce industry's liability by 10%."*

*"No: it should be stopped on schedule."*

*"Who knows?"*

We asked how respondents thought a new or continued version of MEND should be organized: 43 interviewees gave their opinions. Among these, five stated MEND should be terminated:

*"Should be no new MEND."*

*"Could be privatized or contracted to a private company."*

The remaining 38 who wanted an ongoing program of some kind stated preferences which could be grouped into the following possible versions:

- similar to the existing MEND but down-sized either as to number of committees, size of committees, or size of administrative staff (16 responses);
- much the same as the present one, in both form and function (13 responses); or
- with no new research or field projects, but comprising an information exchange function only, with a secretariat to coordinate conferences and/or distribute reports (9

responses).

Some of the suggestions and comments made are given below:

*"Could downsize the Board of Directors. A home for a new MEND might be found within the Canadian Mining Industry Research Organization (CAMIRO), which has replaced both the (MITEC) and the Mining Research Directorate (MRD) of the Mining Industries Research Organization of Canada (MIROC). Or CANMET might provide a home. There should be someone from the environmental movement involved, as well as provincial mining associations."*

*"Focus the activities tightly (primarily tech transfer). Set a short life, say 2 years. Keep the organization simple and the tasks clearly defined (e.g., how many workshops, what reports, what info services, encourage what data collection...). Organizationally, a trimmed down MEND management committee (say 8 members) might provide guidance, and the activity might be housed within CANMET with a link to Mining Association of Canada. Keep it short and simple...KISS!"*

*"Son of MEND: same structure but smaller. Should have a more limited target, concentrating on the most productive areas of study, eg water covers, sludges, dry covers, prediction (is modelling worth the effort? need to refine the prediction methodology and make it more precise). Downsize the committees. The Board of Directors is really a rubber stamp, but is maybe necessary. Need a corporate memory: replace the volunteers over 2-3 years."*

*"Perhaps an annual conference. Or more than that, need some exchange mechanism for distributing information."*

*"This needs to be looked at in light of a decision on what amount and type of work needs still to be done."*

*"Governments should be involved. The Technical Committees are OK as they are. The Management Committee should be smaller in size. The Board of Directors is not needed. There is a need for a centralized office. CANMET could play a useful role as an honest broker between the regulators and the mining companies."*

*"Could drop some of the activities and associated committees, but remain flexible to address needs as they arise. Size of committees not important: but need commitment to solving the problem. Need the federal government to provide coordination and focus."*

*"Collapse the committee structures. Scaled-down version with one technical committee, and a reduced superstructure."*

*"Would be a good thing to try to involve NGO's (i.e., Canadian Environmental Network) in MEND, also academics and perhaps First Nations representatives."*

*"Need to discard the whole budgetary process: it is artificial and obstructive to progress. Keep the secretariat. Reduce committee structure to only two committees: Prediction, and Prevention / Control / Treatment."*

*"Might look similar to existing MEND. Should involve consultants this time. Needs a definite goal and a new name."*

We asked if there might be better ways of producing and communicating MEND's results to the user community. We received 36 responses, of which six were "don't know any". The

remainder (30 respondents) addressed primarily the question of communicating results. The recommendations were as follows:

- some form of communication involving *personal* contact such as workshops, conferences, meetings, individual conversations, etc. (15 respondents). A typical comment:

*"Networking and personal contact are very important."*

*"The workshops are good, and should continue."*

- some formalized or systematized way of distributing information (8 respondents). For example:

*"Data collection function is needed; information must be distributed to all players through some sort of clearing house."*

*"Setting up a home page on the Internet might be a good medium."*

*"On-going program should be organized through the provincial mining associations, with information being shared among the provinces. There would be no need for a central secretariat."*

*"Must have the secretariat as focus. Need more specific focus in committees. Need the backing of the Board of Directors."*

- the provision of traditional published (paper) reports (5 respondents). Comments:

*"The Internet is only a toy for consultants to play with. They **use** books."*

*"People need to have the information on paper. They also need to have*

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*summaries of the work, with an index cross-referencing the original reports."*

- and the use of electronic media, such as publication on the Internet, on compact disks or on videotape (2 respondents):

*"Should try the new communications technologies as appropriate."*

*"Use the Internet as medium for communicating. Use of CDs should be considered. Should not bother with videos."*

We asked interviewees how they thought a continued MEND program should be funded, given the current fiscal restraints being felt by both government and business. Of the 43 who responded, almost half (20 respondents) thought that all three sectors should fund any continuation of MEND. The following are typical answers:

*"AMD is the biggest environmental problem we have: something needs to be done about it, so it must be funded. Government could in fact perhaps reduce the absolute amount of funding they provide, but they should still kick in something to give credibility (and clout) for themselves."*

*"Still need a mix of funding sources, if only to ensure education of regulators (through regular participation of governments)."*

*"May be possible for government to support projects to be carried out by industry. Industry would carry much of the load. Industry should find the partners and organize the funding. Provinces **have** to be there, even if they don't pay."*

However, 16 respondents considered that industry would have no choice but to provide most if not all of the financial support for an ongoing program. On the other hand, it seems clear that all

stakeholders should maintain their decision-making power through continuing to provide at least some funding. Some representative comments:

*"Charge a small fee on waste material, a few cents per tonne, to fund the research. This would tax those causing the problem."*

*"Industry should pay the lion's share: they created the problem, and they profit from the results. On the other hand, large companies shouldn't be able to control everything. The idea of taxing wastes is attractive, but would be hard to operate."*

*"Most funding would have to come from industry."*

*[Respondent sees no funding from governments.] "But non-funders will soon cease to be full participants."*

*"Should try to broaden support through involving forestry and construction industries as well."*

One respondent offered the following example of funding arrangements for a similar program in the USA:

*"The National Mine Land Reclamation Center receives federal block of money as core funding (about \$1M per year). This is used to fund or stimulate three levels of projects: basic research projects costing about \$20-30K each, are paid for directly from the core funding. Small scale demo projects are funded through a 50-50 split between the core funding and other agencies or companies. Large scale demos costing about \$1M each are paid entirely from the outside funding, but coordinated by the center."*

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We asked respondents for their opinions on either or both of the following: first, the appropriate staff strength for a MEND secretariat function, and second, the budget for ongoing research projects.

A total of 36 responses were received commenting on the size of a MEND "headquarters" or secretariat staff. Almost half of these (17 responses) stated they had no idea what would be required or appropriate. Of the rest, a slight majority (10) felt that it should be downsized from the present complement, and should consist of no more than two FTEs, while the others (9) considered the present Secretariat "about right" and recommended a staff of more than two FTEs.

Again, 36 responses were received on the subject of the annual project budget, and ten of these indicated they did not know what to recommend. The remainder expressed their opinions as follows:

- \$0.5 million or less (5 respondents);
- \$1 million (4 respondents);
- \$2 million (3 respondents); and,
- greater than \$2 million (3 respondents).

As might be expected, opinions varied widely among the respondents; the following few quotes indicate this to some extent:

*"Depends on what needs to be done."*

*"Using the model of a central budget to (1) support a secretariat; (2) pay for small projects; (3) share funding of medium-size projects; and (4) coordinate large projects, one would need about \$1M per year."*

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*"Should be 5 to 10 times greater than it has been. Considering the size of the liability, \$18M per year would still be a very reasonable expenditure."*

*"Some of the past experiments have been too site-specific: therefore the budget could be reduced from its current levels. A minimum of \$1M per year to support a research group would be a good way to go. This would be a full-time group tasked with coordinating, performing and directing generic R&D focused on specific, strategically-chosen areas of concern, using various sites as appropriate."*

### **3.9.2 Associates Survey**

The MEND associates were asked if they considered that unfinished business or changing circumstances would suggest a need for future phases of MEND beyond 1997. All respondents stated that there is an ongoing need for continued work in this field. Some of their comments are given below:

*"Tighter controls will need top level R&D to ensure the continuation of mining, and proactive remediation by industry for current and past problems."*

*"Yes: as discussed above, ARD is a long term problem, and many solutions proposed are currently being tested over extended periods. This must continue to allow iterative improvements to be made."*

*"I believe that MEND should continue. Certainly, prediction of post-reclamation water quality needs additional work. Provincial and industry data, if integrated and analyzed, should provide the framework for an extremely valuable field validation study. On a broader perspective, the almost simultaneous demise of the U.S. Bureau of Mines and MEND will*



*leave a tremendous vacuum, and no apparent successor can be seen."*

*"To make sure that there is a follow-up on large scale projects that need to be monitored and properly documented to improve our knowledge of what is happening with real situations."*

### **3.9.3 Telephone Survey of MEND Workshop Attendees**

A total of 47 interviewees in this survey responded to our question: "The MEND Program ends in 1997. Is there a need for further efforts by the federal and provincial governments and the Mining Association in acid mine drainage beyond that time?" Of these respondents, three replied in the negative. The remaining 44 identified a wide range of needs for further work and information that would be useful to them. Three respondents specified their wish for work on biological aspects of AMD:

*"I would like to see its people involved in this type of work given complete courses on the biological and environmental effects on mine drainage."*

*"Research on micro-biology passive treatment."*

*"Treatment, especially biological treatment."*

However, most were expressed in general terms, such as:

*"To follow new developments and to develop further the work that has already started."*

*"The assessment or determination or application of resource recovery and making AMD profitable."*

*"Anything new that can be gathered ? it's more important now than it*

*ever was."*

*"Place more emphasis on actually helping people develop the skills required to address AMD problems."*

*"We need to continue the MEND concept but redefine and perhaps refocus the priority activities."*

#### **3.9.4 Conclusion for Issue 9**

There appears to be significant unfinished business warranting continued collaborative efforts in AMD research; a few examples are biological effects and treatment methods, long-term behaviour of covers, and prediction modelling. Most of those we consulted favoured an ongoing program such as MEND, featuring the dissemination of information by personal contacts (workshops, conferences, etc.), as well as through an organized and systematic data communication system which would include both electronic media and traditional printed reports. The preferred organization was a scaled-down committee structure with a secretariat or central staff group roughly the size of the present one. Most considered that all the existing stakeholders should continue to participate and to provide funding (at the current level or somewhat lower), but that industry should be prepared to pay all costs if absolutely necessary.

### **3.10 Other comments**

#### **3.10.1 Personal Interviews**

The unsolicited opinions and comments expressed by respondents reflected to a great extent mixed feelings: on one hand, MEND is seen by those who know it well as having achieved much success in its stated purpose; yet at the same time, a number of relatively minor complaints were ventilated. Some of these are included in the excerpts given below:

*"Originally was an old boys' club: but that has changed. Regional*

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*interests remain very strong."*

*"MEND is very, very worthwhile, effective and necessary. It has raised environmental awareness. But respondent doesn't know whether it is still necessary. There may be needs for similar activity in other areas: eg, contaminated soils, mine shaft closure techniques, whole issue of subsidence, socioeconomic impact on virgin areas. We need to look at the "big picture" of mining and the environment."*

*"MEND has developed a momentum of its own to some extent. Overall, it has been good, but it's big, heavy, ponderous, and political. The personalities involved have impacted on it."*

*"MEND has had two thrusts: to reduce costs; and to ameliorate environmental impacts. He thinks the second has received only lip service. Not enough attention has been paid to the biological aspects; the measurements are all geochemical, with no biological monitoring."*

*"Good start to document the processes. Poor job selling themselves to general public but good job bringing together government, industry and university."*

*"We haven't moved as far forward as we should. MEND has made achievements, but not as many as it should have."*

*"In general, MEND has been a good cooperative program. There probably wasn't as much communication between "insiders" and "outsiders" as there should have been: this needs more effort."*

*"Another way to view the problem is that the waste rock is an uneconomic source of minerals, i.e., an as-yet unexploited asset or resource. It could*

*be seen as an investment. The federal role should be heavily into work on: marine discharge; permafrost; reducing covers; and international relationships."*

*"The [name on file] has become viewed by environmental NGOs as only a public relations exercise. MEND should take great care not to become like that."*

*"The Secretariat is a good group of people: they are the key to making it all work."*

*"It has been a worth while program. We have got some answers!"*

### **3.10.2 Associates Survey**

Respondents generally expressed their appreciation for MEND's efforts and praised it for the way it has elicited cooperation from all stakeholders. Some of their comments follow:

*"I was impressed by the industry/government cooperation that I witnessed. I think that bringing together the various technical committees really helped look at the issues and problems from a broad perspective."*

*"I found the publications most interesting and often useful for my own area which is the environmental aspects of AMD. However, it would be a great shame if they did not now move on to produce more practical outputs such as Codes of Practice, etc."*

*"As a final note, I'd like to thank the Canadian government and industry for sponsoring such a far reaching effort. I enjoyed participating and established valuable friendships with Canadian regulators and industry personnel."*

*"Great work ? keep doing it."*

*"Emphasis after 1997 should be placed upon large scale applications ? monitoring and data analysis. It is a good program, with some flaws (red tape, too many committees and meetings), but it has benefited the Canadian industry."*

### **3.10.3 Conclusion for Other Comments**

In integrating the unsolicited comments from interviewees and from the associates, we found that **the bottom line was a solid vote of confidence for the way MEND has been structured and managed, and particularly for the committee officers and the Secretariat.**

Irrespective of what respondents thought the next step should be, they were generally very favourable toward the existing organization.

## 4.0 Other Important Issues

### 4.1 Are Costs Really Lower Because of MEND?

#### 4.1.1 Background

Much of the original impetus behind the establishment of MEND came from the realization of the significant liability posed to industry by the existence of acid mine drainage. Although "hard" figures on decommissioning costs are unavailable, the MEND Secretariat estimated in 1994 that Canada faced a liability of nearly \$2 billion for dealing with acid mine waste, even using the lowest-cost options available. The following table reproduces the estimates given by the MEND Secretariat.

In making these estimates, the discount rate selected for calculation of the present value of future maintenance costs was 3% for all options examined, and an annual cost of maintaining a presence ("being there") of \$120,000 was assumed for each 100 hectares of tailings and each 25 million tonnes of waste rock. The pumped water treatment was assumed to be by conventional low density sludge lime treatment technology.

The table shows that the liability for the least costly technology (collecting and treating the drainage for both tailings and waste rock) would be \$1.92 billion, while the most costly technologies (dry soil covers for tailings, and returning waste rock to the pit) would result in an estimated liability of \$5.25 billion.

**Estimates of Acid-Producing Mine Waste Liability in Canada (\$ Billions)**

Problem	Treatment Option	Up-Front Costs	Present Value of Maintenance Costs	Total costs
Tailings (Total 12,562 hectares for	Pump & treat	0.10	1.42	1.52

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**Estimates of Acid-Producing Mine Waste Liability in Canada (\$ Billions)**

Problem	Treatment Option	Up-Front Costs	Present Value of Maintenance Costs	Total costs
Canada)				
	Water cover	1.08	0.45	1.53
	Dry cover	2.07	1.10	3.18
Waste rock (Total 738.9 million tonnes for Canada)	Pump & treat	0.02	0.38	0.40
	Return to pit	2.04	0.03	2.07
	Dry cover	0.37	0.28	0.65

#### 4.1.2 Findings

All in all, MEND has apparently the amount of liability faced by Canada's mining industry, through the increased confidence in predicting the behaviour of tailings dumps and waste rock piles, and the companies' consequent improved ability to manage their individual sites.

Not all costs have been reduced, however. In some cases, respondents reported that the actual costs for opening mines (including design and permitting costs) may be higher or lower than otherwise would have been the case. On one hand, design costs may be lower because of the improved technical knowledge and the consequent reduction in complexity of the decision trees used in formulating disposal and closure plans. For example, one respondent estimated that design costs for a typical mining project before MEND might run to \$500,000. Given the simpler process available now that all stakeholders have the same information, these costs were estimated at about \$100,000 – a saving of \$400,000 per project. On the other hand, design costs may turn out to be higher than formerly was the case, precisely because of the greater awareness of the complex nature of the AMD process. Another respondent commented that

design costs for one project had increased to \$300,000 because of all the various ramifications the consultants had to consider in producing the closure plan.

Second, the projected costs of disposal and closure may be higher or lower, since in days past industry might have been able to expect to simply walk away from a closed site, not realizing that to do so would have caused an ecological mess. Today, companies cannot do this: they must plan to pay for proper closure measures. For example, we were told that the closure bond of \$60 million that had previously been required for a mine in British Columbia had been reduced to a smaller bond of \$30 million, following changes in operations and planning which themselves carried a cost of \$5 million. This reduction in liability of \$30 million, which was attributed largely to the application of MEND technology, obviously represents a significant benefit to the mine owners.

Many existing mines were not designed in the light of modern AMD requirements for operation and closure, and therefore it may be difficult or impossible to apply to specific situations the knowledge MEND has made available. In such cases hindsight is unfortunately the only way to see cost savings in operating or closing a mine. For example, one respondent estimated the actual cost of closing a mine in New Brunswick at about \$100 million. If the disposal site had been originally designed according to the information now available through MEND, it was estimated that closure costs could have been held to about \$5 million.

At least, MEND provides more options for consideration, and some of these options may permit satisfactory handling of potentially acid-generating materials at reduced costs. For example, we were told that, at a mine in British Columbia, the initial cost of \$40 million for a dry cover was offset by the consequent reduction by a factor of about ten in the cost of long-term collection and treatment of acid drainage. But we were also told that, frequently, collection and lime treatment of the drainage is still the only workable option, so that the technology developed and demonstrated under MEND cannot always be of use in reducing operating and closing costs.

Costs for rehabilitating abandoned mines are even more unpredictable. However, the increased



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understanding of the AMD process that MEND has made available has shown that sometimes the best (and cheapest) course of action is to leave an old site undisturbed, and to simply collect and treat the drainage water as required.

It was difficult to obtain even rough estimates of real or potential cost savings from respondents. The rough estimates for specific sites or companies, given in the Table on the following page, are not official figures, but are only an indication of the order of magnitude of possible costs and savings.

#### **4.1.3 Conclusion**

For the five cases where respondents gave us estimate of reductions in costs, the total (conservatively estimated) savings of \$340 million are more than an order of magnitude greater than the total MEND budget of about \$18 million. Further, comparing these savings to the total estimated mining industry liability of \$2 - 5 billion, (see section 4.1.1 above), it is tempting to say that MEND has achieved its target of a ten percent reduction in liability. However, we also were told that costs may have been reduced for individual mining companies, or they may have been increased ? so these estimated savings should really be offset against the (unknown) increased costs. Perhaps the bottom line is best stated by one of our respondents:

*"The costs may well be higher for our company, but at least we are more certain we're doing the job right."*

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### Estimated Cost Savings for Some Mine Sites

**New copper & zinc mine:**

Estimated potential costs, without MEND information:

Cost to build .....	\$20 million
Cost to close .....	\$30 million
Total potential cost .....	\$50 million

With underwater disposal design based on MEND findings:

Actual cost to build .....	\$10 million
Forecast ongoing maintenance costs after closure .....	negligible
Total actual forecast cost .....	\$10 million

Overall saving ..... \$40 million

**Existing nickel operation (two respondents' estimates):**

Savings, all sites in one region, 300-year period .....	\$100 million
Reduction in liability, all existing tailings sites .....	\$650 million
Total savings, conservative intermediate estimate .....	\$250 million

**Existing nickel operation, one site:**

Cost of complex covers previously required .....	\$18 million
Cost of grass cover permitted by designed design .....	\$0.6 million
Savings for this site .....	\$17 million

**Existing gold mining company, all sites:**

Estimated potential savings, all sites ..... \$10 million

**Inactive copper mine, one site:**

NPV of potential cost of collection and treatment, 50 years .....	\$25 million
Estimated total cost of water cover .....	\$2.1 million
Estimated savings for this site .....	\$23 million

**Lower limit to total savings for above five cases ..... \$340 million**

## **4.2 Underwater Disposal of Tailings and Waste Rock**

### **4.2.1 Background**

Because of the potential it holds for the implementation of low-cost perpetual management of tailings and waste rock, underwater disposal is considered by many to be the best available technology, and the first choice for disposal designs.

The underwater disposal technique was known, at least to some, as an effective disposal method even before the advent of MEND. For example, one company received a dispensation from the federal Minister of Fisheries to dump tailings into a natural lake in Manitoba as early as 1978-79, and this idea was apparently based on an even older successful underwater disposal site in the same area. Consulting engineers were apparently well-aware of the technology as well.

Underwater or subaqueous disposal is now widely accepted in Canada as a practical and effective method of preventing acid generation, largely as a result of MEND's testing and promotion.

### **4.2.2 Issues**

In our review of MEND, we identified three issues concerning underwater disposal, based on comments from respondents. The first issue is the use of artificial disposal ponds rather than natural lakes. The second question concerns disposal under saltwater: submarine rather than subaqueous. And the third relates to the general question of biological effects due to underwater disposal of both tailings and waste rock.

It is clear that man-made ponds have two advantages: their size and depth can be controlled fairly easily, and the public does not generally view them as part of an environmental heritage. On the other hand, there are some disadvantages: levees or dykes can leak, dams can burst and impoundments can dry up in times of low rainfall. Any of these occurrences would result in

the exposure of the acid-generating material to atmospheric oxygen and rainwater, and the consequent risk of contaminating the local surface water. For example, one new mine in Québec has a tailings pond impounded by two dams at either end of a natural valley. Concern has been expressed by provincial regulators that the dams might leak or break; the operators maintain that the engineering design is conservative, and that continual and prolonged monitoring will be carried out on the dams and surrounding areas.

In contrast to artificial ponds, natural lakes are generally deeper and therefore less likely to dry up. But they usually are home to plankton, invertebrates, fish, waterfowl and other wildlife, and therefore are the subjects of concern on the part of environmental groups, hunting and fishing associations, and the general public. We were told by one regulator that MEND has left the impression that underwater disposal is a harmless and even benign intervention in the ecology of natural lakes, but that it would never be accepted by environmental interest groups or the public at large. On the other hand another provincial regulator has been quoted as saying during the 1980's that mine tailings could only be dumped in Ontario lakes "over his dead body", while now in the mid-1990's, we were told that at least one company has actually been requested to consider such disposal sites. The question of disposal in natural lakes now seems to be an open one.

We were told that, early in its history, MEND apparently made a decision to consider only freshwater disposal as a technique to be tested and demonstrated. Considering the great distances between most Canadian mines and salt water, this decision seems eminently reasonable. However it was seemingly the cause of some dissatisfaction when proposals for the study of submarine disposal were rejected. While some Canadian studies of salt-water disposal exist, the ones we have seen all refer to a half-dozen sites in the waters off British Columbia. There may of course be other factors which might affect submarine disposal off other Canadian coastlines.

Finally, many respondents commented to us that the biological effects of subaqueous disposal have in general not yet been considered by MEND. This is understandable for several reasons: first, biological studies have not been part of MEND's mandate (and are in fact under the

purview of at least two other cooperative programs, AQUAMIN and AETE); and second, most MEND participants, both from government and industry, have backgrounds in mining or other engineering fields, not in biology. However, from our interviews, we consider it fair to say that all MEND participants would agree that the preservation of the environment does not end with the maintenance of a suitably-neutral *pH* in the surface water. The well-being of the biota naturally occurring in that water is also a worthwhile goal, albeit one which has been purposely not studied by MEND because of the complexity of the processes occurring at each individual site.

#### **4.2.3 Conclusion**

Underwater or subaqueous disposal of tailings and waste rock is seen as an extremely valuable technology for preventing acid generation, especially for freshly-produced material. But it is not a panacea or cure-all: there are always risks and unknown factors. There is the risk that man-made tailings ponds may leak or dry up; the use of natural lakes carries the risk of unforeseen environmental damage and consequent public disapproval; submarine disposal must necessarily involve consideration of perhaps unknown and powerful forces associated with depths, currents and the sheer extent of the ocean; and the complexity of the inter-related biological ecosystem present in all aquatic environments, whether freshwater or marine, poses many sometimes baffling challenges. Finally there is the simple, unescapable physical fact that many old or existing sites simply cannot be submerged. MEND has provided and promulgated a body of engineering knowledge which can greatly facilitate the successful management of these risks, in support of industry's sometimes difficult decisions on the choice between water covers and other possible technologies.

### **4.3 *MEND Workshops ? Winners in Technology Transfer***

#### **4.3.1 Background**

MEND currently presents several workshops each year, on a series of topics of interest and concern in the AMD field. They are conducted in different regions of the country, and are both well-regarded and well-attended. From our telephone survey of workshop attendees, from comments made by a few respondents in the Personal Interviews, and from attendance data gathered at five recent workshops, this section discusses the "reach" of this clearly-effective technology transfer medium.

#### **4.3.2 Client satisfaction**

MEND workshop clients found the MEND-supported technology transfer workshops quite useful. Of the 51 respondents to our telephone survey of workshop attendees, 96% considered the workshops to be either "very useful" (43%) or "useful" (53%). When we asked them to compare MEND workshops to other workshops (on similar or other topics), 44% considered MEND workshops to be "better" (36%) or "much better" (8%) than the ones offered by other groups.

We compared these findings with a "benchmark" study based on a survey conducted of 281 participants in workshops, offered on diverse subjects, by 20 Canadian technology centres in 1994. Exactly the same questions, interview protocols, and interviewers were used in each case ? including the present MEND study.

We found the MEND results, while within the statistical range of scores from the benchmark study, were somewhat more positive. **Figures 3 and 4** illustrate these findings. In Figure 3, MEND workshops were rated slightly higher under "very useful" and "useful", as well as scoring slightly fewer respondents who considered them "not very useful" or "not at all useful". Similarly in Figure 4, where the MEND workshops were compared with workshops offered by other groups (not necessarily on the same subjects, of course), MEND rated a significantly higher score than the benchmark in the "better" category, as well as significantly less in the "about the same" and "poorer" categories.

Figure 3: Overall How Useful was the Workshop?

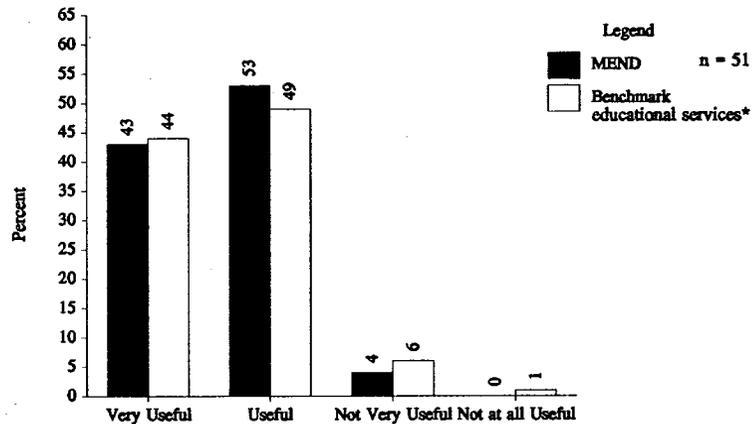
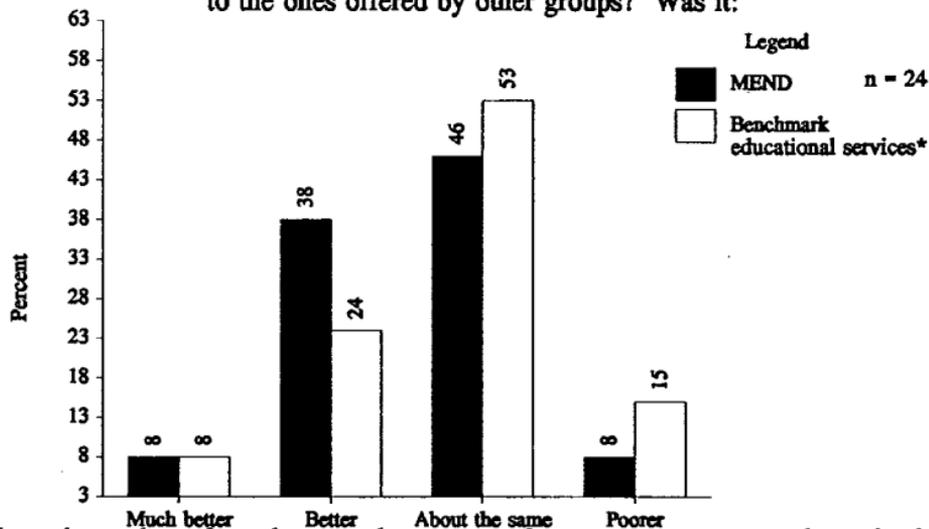


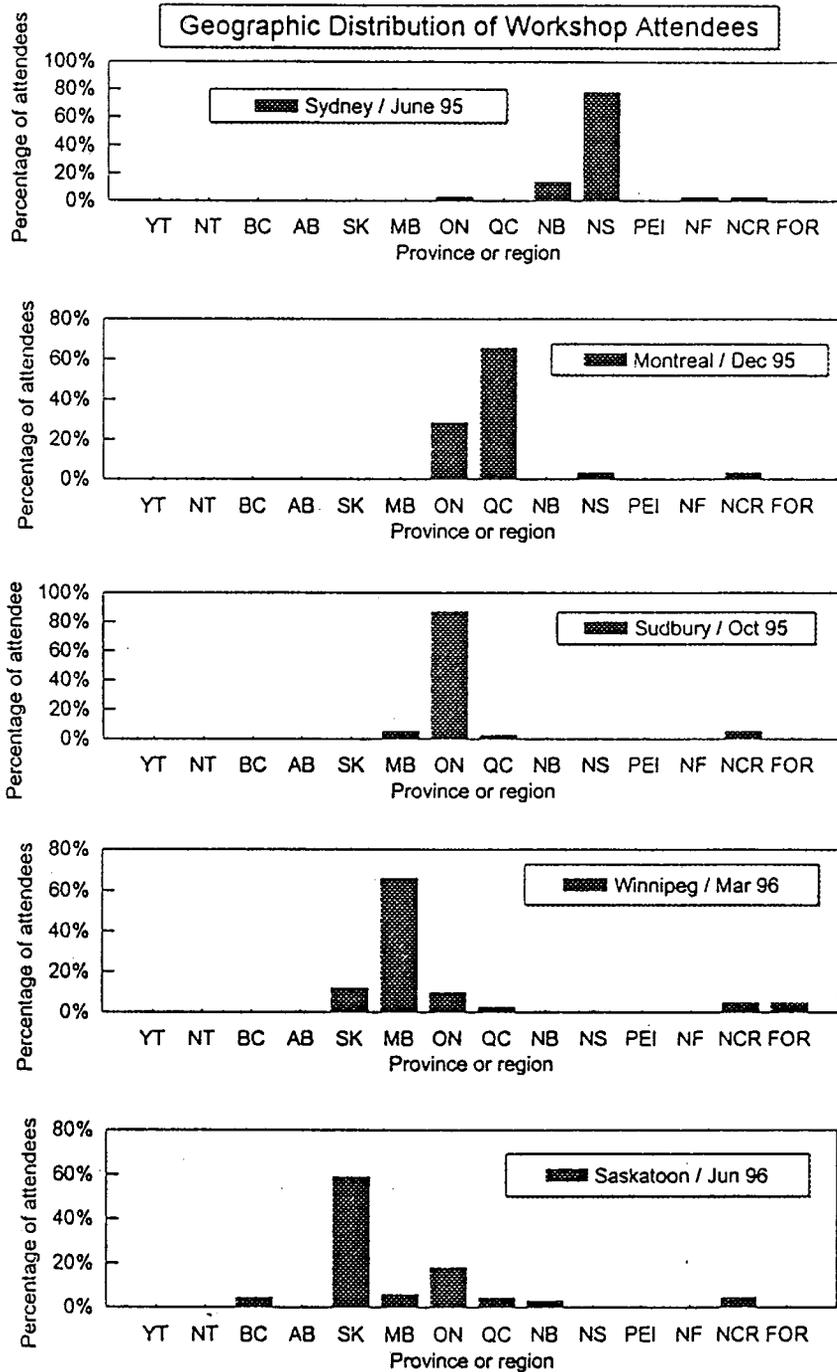
Figure 4: How did the MEND workshop compare to the ones offered by other groups? Was it:



\* The benchmark study referred to in this case refers to a survey conducted of 281 participants in workshops offered by 20 diverse Canadian technology centres in 1994. The exact same questions, interview protocols, and interviewers were used in each case.



Figure 5



### **4.3.3 Regional distribution of workshop attendees**

We were told by more than one respondent in the Personal Interviews that MEND should definitely continue its practice of conducting workshops in the different regions of Canada. The reason for this is a simple economic one: far more small mining companies, consultants, universities and provincial departments would be able to afford to send participants to venues which were close to home.

The attendance data for five recent workshops demonstrates this rather well. The composite chart of **Figure 5** on the following page shows the distribution of attendees from different provinces or regions, for each workshop. The group participating in each workshop was definitely localized, mainly from the province in which the workshop was held, with only a small number coming from other, mostly nearby, parts of Canada.

### **4.3.4 Affiliations of workshop attendees**

One respondent commented that, in general, the workshops were getting poor attendance from governments and industry, and that most attendees were students. This is certainly not the case for the five workshops referred to in the preceding section. There, the attendance data revealed that most attendees were in fact from consulting engineering firms (31%), with the mining industry second (26%) and the provincial (16%), university (14%) and federal (13%) representatives virtually tied for third place.

Another respondent expressed the hope that there was some turnover in the attendance, that is, that MEND was not always reaching the same group of attendees. A comparison of the attendance lists among the same five workshops mentioned above revealed that of a total of 215 names on the composite list, there were only seven attendees who had each participated in two of the five events (not counting organizers). These multiple attendees comprised one from industry, two consultants, two federal regulators and two provincial regulators.

## **5.0 Recommendations**

In this section, we suggest changes and developments that MEND's Board of Directors and Management Committee should consider when planning the future course of this program.

To avoid repetition, we have stated the recommendations, along with a very brief rationale for each one, and referenced the appropriate sections of this evaluation report, in which the supporting findings and conclusions are found.

### **5.1 Technology Transfer**

- 5.1.1 MEND should expand and extend its technology transfer products and services. In particular, regional workshops should continue to be offered and actively promoted, and a comprehensive MEND Manual should be produced and made available as soon as possible.

While major stakeholders in MEND are in general well aware of its findings and results, there is a significant demand for this knowledge among other stakeholders who have not been actively involved in the program. The workshops are highly rated by their participants as an effective way to distribute and disseminate the research results of MEND. Other technology transfer media, especially the long-awaited MEND Manual, are also seen as important by users of the information (section 3.6: Technology Transfer; page 35).

**5.2 *Focus of MEND's Activities until Anticipated Completion in 1997***

- 5.2.1 MEND should focus, first, on the orderly completion of its unfinished projects, and second, on the documentation and dissemination of results from all its completed work. Results should be prepared in a user-friendly form.

Many of the respondents to our surveys indicated that they would like to see the existing projects completed in a timely and orderly fashion, including the production and distribution of reports on the project results (section 3.8: Recommended focus until 1997; page 46).

**5.3 *Unfinished Business and Ongoing Need for MEND***

- 5.3.1 A program similar to MEND should be designed and put into place to continue work on selected topics of research on acid mine drainage, including biological effects of AMD; biological methods of treating AMD; long-term behaviour of covers; and predictive techniques for new mines and existing waste deposits.

Many respondents to our surveys identified unfinished business or future topics of AMD research which they considered appropriate for investigation by a program similar to MEND (section 3.9: The next step; page 49).

- 5.3.2 This new program should resemble the present MEND in its organizational structure, but consideration should be given to reducing the number and size of committees (including both administrative and technical committees). Electronic methods of communication should be used.

- 5.3.3 The secretariat function should continue to be provided by Natural Resources Canada at its current level of resources, and if possible with no break in operations, to ensure continuity of information transfer.

- 5.3.4 Membership on all boards and committees should include representatives of federal government scientists, federal and provincial regulators, major and junior mining companies, universities and consultants.
- 5.3.5 Funding for the new program should depend on the research projects chosen (in the region of \$1 million per year), and should be provided from all the major partners. A budget should be negotiated between the partners on a multi-year basis to permit long-range project planning.

Consideration should be given to an arrangement which would see approximately seventy-five percent of the project budget coming from industry and the remainder from the other partners.

The recommendations listed above are all based on comments and suggestions made by the majority of respondents in our surveys (section 3.9: The next step; page 49).

#### **5.4 *Lessons Learned***

- 5.4.1 MEND, and any successor program(s), must continue to involve as many stakeholders as possible in its forum of research, discussion and decision-making.  
Virtually all respondents agreed that MEND's structure and modus operandi have resulted in a tremendous synergism, as stakeholders with very different priorities and agendas came together to address a common problem and to work together to find practical and realistic solutions. Several of the respondents commented very favourably on the good level of participation that MEND had engendered among the various stakeholders (section 3.5: Lessons learned from the MEND experience; page 28).
- 5.4.2 The MEND Secretariat should monitor more carefully the management of research projects, and report promptly to the Management Committee on any lapses in timeliness or effectiveness.

Stakeholders and funders of MEND projects have a natural expectation that good project management practices will be observed; some of our respondents indicated that this is not always the case (section 3.5: Lessons learned from the MEND experience; page 28).

*Appendices*

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**Appendix A: Summary of Survey Respondents**
**Personal Interviews:**

Note that in the following table individual respondents from "resource-oriented" departments are listed separately from those from "environment-oriented" departments, both federally and provincially.

Category	Number
Industry	19
Federal government: "Resource" departments	5
"Environmental" departments	4
Provincial governments: "Resource" departments	8
"Environmental" departments	5
Mining associations	4
Consulting engineers	6
Environmental groups	1
Other experts	2
Total	58

The following table shows the degree of coverage of MEND board and committee members. The number of committee members interviewed shown here exceeds the total number of individuals actually interviewed, since duplicate names have been counted in giving both the total membership and the number interviewed.

MEND Committee	Number of Members		
	Total	Interviewed	Percent
Board of Directors	20	10	50%
Management Committee	27	22	81%
Technical committees	75	28	37%
Total	122	60	49%



**Associates Survey:**

The following table shows the geographical location of the respondents to the fax survey of MEND Associates.

<b>Location</b>	<b>Number</b>
Canada	2
United States	2
Europe	1
Australia	1
Total	6

**Junior Mining Companies Survey:**

The following table shows the geographic locations of respondents to the telephone survey of junior mining companies.

<b>Location of Respondent</b>	<b>Number</b>
British Columbia	9
Ontario	5
Québec	1
North West Territories	1
Total	16

**Workshop Clients Survey:**

The following table shows the category of the respondents to the telephone survey of MEND workshop attendees.

<b>Category</b>	<b>Number</b>
Industry	12
Federal government	5
Provincial government	8
Consulting engineers	19
University	6
Other affiliation	1
Total	51

*Appendix B: Detailed findings from Main Survey*

**Issue 1: To what extent has MEND provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock?**

1.1 Before the MEND program was begun, do you think [your company / the mining industry] had the ability to predict the long-term behaviour of its tailings and waste rock disposal sites, with any sense of confidence that the predictions would be valid?

Category	No understanding	Knew problem, not solution	Understood AMD but not applied	Don't know	Total	No response
Industry	5	11		2	18	
Federal gov't	1	4		1	6	2
Provincial gov't	2	6	2	1	11	
Associations	1	1	1		3	1
Consultants	1		3	2	5	
Others		1	1		2	1
Summary	10	23	7	6	46	4
Percent	22%	50%	15%	13%	100%	

1.2 What sort of experience did [your company / the mining industry] have with disposing of tailings or waste rock? Can you describe any successes in handling these problems? Any unsuccessful stories?

**Legend:**

1	Equity Silver
2	Sullivan Mine
3	Elliot Lake
4	Brunswick Mining & Smelting
5	Heath Steele
6	Kam Kotia
7	Waite Amulet

Category	1	2	3	4	5	6	7	Other	Don't know	Total	No response
Industry	3	1	2		1		2	11		20	1
Federal gov't		1				1		2	1	5	4
Provincial gov't		1		2	1	1		7		12	
Associations											4
Consultants			1					3		4	2
Others	1	1								2	2
Summary	4	4	3	2	2	2	2	23	1	44	13
Percent	9%	9%	7%	5%	5%	5%	5%	53%	2%	100%	

1.3 What sort of results has MEND come up with that you think should lead to more successes in this area? Or fewer problems?

Category	Underwater disposal	Dry covers	Broad spectrum	Don't know	Total	No response
Industry	9	3	5		17	4
Federal gov't	1		4	1	6	2
Provincial gov't	3	1	6		10	2
Associations	1	1			2	3
Consultants	3	1	3		7	
Others			2		2	1
Summary	17	6	20	1	44	12
Percent	39%	14%	45%	2%	100%	

1.4 What have been the positive and negative outcomes of MEND?

Category	Positive			Negative	Don't know	Total	No response
	Tech. info	Coop'n	Other				
Industry	5	5	2	3		15	7
Federal gov't		2	1			3	5
Provincial gov't	5		1	5		11	1
Associations		1				1	3
Consultants	1	2		1		4	2
Others	1	1		2		4	
Summary	12	11	4	11	0	38	18

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Percent	32%	29%	10%	29%	0%	100%	
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1.5 Has MEND produced results that are adequate for use by [your company / the mining industry] on a scientific or technical level?

The responses to this question were generally very similar to each other, but with minor variations. Almost all were complex in nature, and did not lend themselves to a simplistic tabulation as used in the other questions.

1.6 How useful or comprehensive are MEND's results on the economic level? That is, do you feel they are practical and affordable? Why do you say that?

Category	Useful as guide or tool	Generally approving	Not useful	Don't know	Total	No response
Industry	11	4			15	3
Federal gov't	1	3		2	6	2
Provincial gov't	7	1		1	9	2
Associations			1		1	3
Consultants	3	2			5	1
Others	1			1	2	1
Summary	23	10	1	4	38	12
Percent	60%	26%	3%	11%	100%	

**Issue 2: What has been MEND's contribution to reducing the harmful impacts on the environment of acid mine drainage?**

2.1 Are you aware of any of MEND's projects or findings that have helped to reduce harmful impacts on the environment?

**Legend**

1	Louvicourt
2	Equity Silver
3	East West Caribou
4	Other sites

**Legend:**

Category	Water covers	Dry covers	1	2	3	4	Non-spec.	No impacts	Don't know	Total	No response
Industry	4	1	4			3	4			16	4
Federal gov't			1				3	2		6	2
Provincial gov't	1				2	5	1	2		11	1
Associations				1		2				3	2
Consultants	1					3	1			5	1
Others				1		1	1			3	1
Summary	6	1	5	2	2	14	10	4	0	44	11
Percent	14%	2%	11%	4%	4%	33%	23%	9%	0%	100%	



2.2 Can you describe any potential reductions that perhaps have not yet happened, but that could be ascribed to MEND if they come to pass?

Category	Water covers	Dry covers	Louvi-court	Other sites	General	None known	Total	No response
Industry	1	3		3	1		8	11
Federal gov't			1	1	1	1	4	4
Provincial gov't		1	1	1	2	1	6	5
Associations							0	4
Consultants	1	2	1				4	2
Others				1			1	2
Summary	2	6	3	6	4	2	23	28
Percent	9%	26%	13%	26%	17%	9%	100%	

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**Issue 3: Have MEND's R&D products resulted in net reduced costs associated with opening new mines, operating and closing existing mines, and in rehabilitating abandoned mine sites?**

- 3.1 Are you familiar with the various "products" MEND generates, such as technical reports, workshops and larger meetings?

This question was provided to the interviewer to use as a "filter" in case it was necessary as a lead-in to the other questions 3.2, 3.3 and 3.4. In most interviews it proved to be redundant, since when it was asked, almost all respondents simply answered: "Yes."

- 3.2 Can you say whether any of these products has resulted, as yet, in net reduced costs to [your company / the mining industry] which are associated with, say, the opening of new mines?

Category	Incr. costs	Decr. costs	Red. risks	Made poss.	Not yet	Don't know	Total	No response
Industry	2	5	3	1		1	12	7
Federal gov't		2			3	1	6	2
Provincial gov't	3	2	4			1	10	2
Associations		2					2	2
Consultants	2	3	1			1	7	
Others	1	1					2	1
Summary	8	15	8	1	3	4	39	14
Percent	20%	39%	20%	3%	8%	10%	100%	

3.3 How about costs associated with operating and closing existing mines?

Category	Incr. cost	Decr. cost	No change	More confid.	Don't know	Total	No response
Industry	2	9	1	4		16	3
Federal gov't	1	2	1	1	1	6	2
Provincial gov't	2	3	3	2		10	2
Associations		1				1	3
Consultants	1	2	1	3		7	
Others		2				2	1
Summary	6	19	6	10	1	42	11
Percent	14%	46%	14%	24%	2%	100%	

3.4 Has MEND been instrumental in reducing costs of rehabilitating abandoned mine sites, to your knowledge?

Category	Incr. cost	Decr. cost	No change	More conf.	Budget constr.	No problem	Don't know	Total	No response
Industry		3	3	3	1	1	1	12	7
Federal gov't			2				1	3	5
Provincial gov't		2	1	5	1	1		10	1
Associations			1		1	1		3	1
Consultants	1		2		1			4	2
Others				1	1			2	1
Summary	1	5	9	9	5	3	2	34	17
Percent	3%	15%	26%	26%	15%	9%	6%	100%	

**Issue 4: In what manner and to what extent has MEND contributed to setting more realistic regulatory requirements, and to making the regulatory process less complex and more efficient?**

4.1 Do you feel that MEND has contributed to governments setting more realistic regulatory requirements *vis-à-vis* the handling of reactive mine tailings and waste rock?

Category	Attitude change	More conf.	Yes (gen.)	MEND N/A	No change	Don't know	Total	No response
Industry	2	1	1		1		5	13
Federal gov't		2			3		5	3
Provincial gov't	2	3	1		1		7	4
Associations		1					1	3
Consultants	1			2			3	3
Others					1		1	2
Summary	5	7	2	2	6	0	22	28
Percent	23%	32%	9%	9%	27%	0%	100%	

4.2 How would you say that MEND has been able to influence these regulations?

Category	Att. chg.	More coop'n	Easier in gen.	No infl.	Don't know	Total	No response
Industry	2	3	1			6	12
Federal gov't		2	1	3		6	2
Provincial gov't	4					4	7
Associations			2			2	2
Consultants	1	2			1	4	2
Others		1				1	2
Summary	7	8	4	3	1	23	27

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Percent	30%	35%	17%	13%	4%	100%	
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4.3 To what extent have changes in regulations been attributable to MEND's existence?

Category	Data used in policy, etc.	Process facilitated	No change	Don't know	Total	No response
Industry	1	4	2		7	11
Federal gov't	1	1	3		5	3
Provincial gov't	3	2			5	6
Associations	1		2		3	1
Consultants	2	1	2	1	6	
Others			1		1	2
Summary	8	8	10	1	27	23
Percent	30%	30%	37%	4%	100%	

4.4 Do you think the regulatory process has become less complex and more efficient because of MEND? In what ways? And, to what extent?

Category	Less complex	More complex	No change	Don't know	Total	No response
Industry	4	3	4		11	7
Federal gov't	3	2	1		6	2
Provincial gov't		3	2		5	6
Associations			1		1	3
Consultants		4		1	5	1
Others		2			2	1
Summary	7	14	8	1	30	20
Percent	23%	47%	27%	3%	100%	

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**Issue 5: Has the design and delivery of MEND influenced its performance? What are the lessons learned?**

- 5.1 MEND has been a process which has involved the federal government, many of the provincial governments, and some of the mining companies. Do you think the way it was set up, and the way it has operated, have influenced the effects it may have had on the various participants? How?

The responses to this question were generally very similar to each other, but with minor variations. Almost all were complex in nature, and did not lend themselves to a simplistic tabulation as used in the other questions.

- 5.2 What about others who have not participated? Mining companies? Provinces?

Category	Data avail.	Concerned about...			None to others	All benefit	Reg'rs police	Don't know	Total	No re-sponse
		Jrs	Provs	Cons						
Industry	6	2	1		2	3	3	1	18	1
Federal gov't	3				1	1	1		6	2
Provincial gov't	2	2			1	3	1		9	2
Associations	1					2			3	1
Consultants	1	1		2	1				5	2
Others	1					1	1		3	
Summary	14	5	1	2	5	10	6	1	44	8
Percent	33%	11%	2%	4%	11%	23%	14%	2%	100%	

5.3 What lessons do you think can be learned from the "MEND experience"? Are there features about it that could be copied with advantage to address other problems or situations where players from different sectors are involved? Has anything become apparent to you that would indicate things about MEND that should definitely not be repeated in the future?

Category	Inv. oth.	Cttees top heavy	Budget too much concern	Good partic.	Proj. mgt	Other	N/A	Don't know	Total	No resp.
Industry	4	6	4	1	2	3	2		22	2
Federal gov't	2			1	1			1	5	4
Provincial gov't	4	5	2			1			12	1
Associations	1			1			1		3	2
Consultants	1		1	3	2	1			8	
Others	1		1	1					3	1
Summary	13	11	8	7	5	5	3	1	53	10
Percent	25%	21%	15%	13%	9%	9%	6%	2%	100%	



**Issue 6: To what extent have the technology transfer activities of MEND succeeded in informing the target audiences about the issues of acidic drainage and about the technologies which can deal with the problem? To what extent is decision-making on acid mine drainage now based more on science and technology considerations as a result of MEND?**

6.1 What kind of activities does MEND carry out under the general heading of "*Technology Transfer*"?

This question was provided to the interviewer to use as a "filter" in case it was necessary as a lead-in to the other questions 6.3 and 6.4. In most interviews it was not necessary to ask it; when it was asked, almost all respondents were able to enumerate most of the usually well-known technology transfer media used by MEND.

6.2 What target audiences are supposed to be addressed by each of these various TT activities?

This question, like 6.1, was provided to the interviewer to use as a "filter" in case it was necessary as a lead-in to the other questions 6.3 and 6.4. As in the previous question, in most interviews it was unnecessary; when asked, almost all respondents identified the target audiences as "industry, regulators and consultants." Some also named academia, international audiences, and the general public.

6.3 Do you think that MEND has succeeded in reaching these audiences? In your opinion, have they become more informed about the issues involved in acid drainage? Do you find that the technologies devised or developed through MEND projects are becoming known to the appropriate audiences?

Category	Yes	Could do more	No	Don't know	Total	No response
Industry	8	8	2		18	2
Federal gov't	2	3		1	6	2
Provincial gov't	4	3		2	9	2
Associations	2			1	3	1
Consultants	2	3	1		6	
Others	2	2			4	
Summary	20	19	3	4	46	7
Percent	44%	41%	6%	9%	100%	

6.4 Do you think that decisions in this area are based more on science and technology considerations as a result of MEND's activities? If so, why? (Or, if not, why not?)

Category	Yes	No	Partly	Don't know	Total	No response
Industry	2	1	1		4	14
Federal gov't	1	1	1		3	5
Provincial gov't			3		3	8
Associations					0	4
Consultants	1		1	1	3	3
Others					0	3
Summary	4	2	6	1	13	37
Percent	31%	15%	46%	8%	100%	

**Issue 7: Has MEND influenced the image and credibility of the mining industry regarding protection of the environment? In what manner and to what extent has MEND contributed to enhancing Canadian leadership internationally in the science and technology of the prevention of acid mine drainage?**

7.1 Presumably some of the target audiences for MEND's communications efforts might be politicians, environmental activists and the general public. Do you feel that MEND has in any way influenced the image and credibility of the mining industry regarding protection of the environment, among these three groups?

Category	Yes	No	Partly	Don't know	Total	No response
Industry	1	9	5	1	16	2
Federal gov't		2	3	2	7	1
Provincial gov't		4	5		9	2
Associations		3			3	1
Consultants		3	2		5	1
Others		1	2		3	
Summary	1	22	17	3	43	7
Percent	2%	51%	40%	7%	100%	

7.2 What about Canada's international image in this field? Is Canada considered a leader in the science and technology of the prevention of AMD?

Category	Yes, due to ...			No	Don't know	Total	No response
	General	Initiative	Conferences				
Industry	15		2			17	1
Federal gov't	4		1		2	7	1
Provincial gov't	6	2	1		1	10	1
Associations	3					3	1
Consultants	5					5	1
Others	1			1		2	1
Summary	34	2	4	1	3	44	6
Percent	77%	4%	9%	2%	7%	100%	

7.3 Has MEND contributed in any way to enhancing Canada's reputation in this area? How has it done so? To what extent? Have we missed any opportunities? Why?

Category	Yes					No	Don't know	Total	No response
	Conf.	Cons.	Secr.	Info diss.	Gen'l				
Industry	6	3	3		6	1		19	3
Federal gov't	1				4			5	3
Provincial gov't	4		2	1	2	1	1	11	3
Associations	1				1			2	2
Consultants	4	1			2			7	1
Others	1	1		1	1			4	1
Summary	17	5	5	2	16	2	1	48	13

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Percent	36%	10%	10%	4%	34%	4%	2%	100%	
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**Issue 8: What should be MEND's focus until its anticipated completion in 1997?**

8.1 MEND is scheduled to end in 1997. What should be the focus during the last year or so of the program?

Category	Finish up	Manual	Tech. trans.	Plan for cont'n	Eval. work	Vanc. conf.	Don't know	Total	No response
Industry	12	8	3	4	2	2		31	2
Federal gov't	5	2	2		1			10	
Provincial gov't	7	4	3	1				15	1
Associations			1		1			2	2
Consultants	3	4	4	1				12	
Others	3	1	2	1		1		10	
Summary	30	19	15	7	4	3	0	78	5
Percent	39%	24%	19%	9%	5%	4%	0%	100%	

8.2 Please expand on your reasons for suggesting that this area [these areas] would be important.

Category	Econ. imp.	Cons. mom.	Other reason	Don't know	Total	No response
Industry		3	2		5	13
Federal gov't	2	2			4	4
Provincial gov't		2	3		5	6
Associations					0	4
Consultants			1		1	5
Others		1			1	2
Summary	2	8	6	0	16	34
Percent	12%	50%	38%	0%	100%	

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**Issue 9: Is there unfinished business or changing circumstances that would suggest a need for future phases of MEND beyond 1997? If so, how should MEND be constructed and delivered, and what are the cost implications?**

9.1 Has MEND now addressed all the important problems associated with AMD?

Category	Yes	No	Don't know	Total	No response
Industry	4	7		11	7
Federal gov't	2	3	2	7	1
Provincial gov'ts	3	3	1	7	4
Associations	1			1	3
Consultants		1		1	5
Others		2		2	1
Summary	10	16	3	29	21
Percent	34%	55%	10%	100%	

9.2 Is there any unfinished business which needs to be followed up?

Category	Response		Don't know	Total	No response
	Topic	No.			
Industry	Long-term behaviour; permafrost; prediction; sludge; biology	15	1	16	2
Federal gov't	Biological; permafrost; sludge; abandoned sites	6	2	8	
Provincial gov'ts	Waste rock; long-term; biology	9		9	2
Associations	Various needs; cover effectiveness, alternatives, prevention, monitoring	2	1	3	1
Consultants	Various needs	4		4	2
Others	Avoidance; long-term treatment; summary of completed work; sewage sludge; prediction; tech transfer; alkaline drainage	3		3	
Summary	Long-term behaviour; prediction; biology; sludge; prediction & prevention	39	4	43	7
Percent		91%	9%	100%	

9.3 Have circumstances changed in any way that would indicate the need for a continuation of MEND in the future?

Category	Should continue	Break to decide	Don't continue	Don't know	Total	No response
Industry	7	2			9	9
Federal gov't	2		2		4	4
Provincial gov'ts	2		4		6	5
Associations					0	4
Consultants	1				1	5
Others	2				2	1



Summary	14	2	6	0	22	28
Percent	64%	9%	27%	0%	100%	

9.4 If so, how would you suggest a new or continued version of MEND should be organized or constructed, to do what is necessary?

Category	Down-size	Same	Info. exch.	Terminate	Don't know	Total	No response
Industry	7	4	3			14	4
Federal gov't	3	3	1			7	1
Provincial gov'ts	4	1	4	1		10	1
Associations	1	1		1		3	1
Consultants	1	1	1	3		6	
Others		3				3	
Summary	16	13	9	5	0	43	7
Percent	37%	30%	21%	12%	0%	100%	

9.5 Is the past and present method of program delivery adequate for the likely future needs of the Canadian mining industry? That is, if MEND were to be continued, are there better ways of producing and communicating its results than the current way of doing business?

Category	Personal contacts	Info. system	Paper reports	Electr. media	Don't know	Total	No response
Industry	6	2	2		4	14	4
Federal gov't	3	2				5	3
Provincial gov'ts	6			1	1	8	3
Associations		1				1	3
Consultants		3	1		1	5	1
Others			2	1		3	
Summary	15	8	5	2	6	36	14

Percent	42%	22%	14%	6%	17%	100%	
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9.6 How would a continued MEND program be funded, given the current fiscal constraints being felt by both governments and business?

Category	By industry	By all sectors	Don't know	Total	No response
Industry	7	6	3	16	2
Federal gov't	3	3	2	8	
Provincial gov'ts	5	3	2	10	1
Associations	1	1		2	2
Consultants		5		5	1
Others		2		2	1
Summary	16	20	7	43	7
Percent	37%	46%	16%	100%	

9.7 What sort of annual budget level do you think might be needed to address the problems and tasks that would be associated with a future version of MEND?

Category	HQ size				Project budget						No response
	•=2	>2	Don't know	Total	•=0.5M	1M	2M	>2M	Don't know	Total	
Industry	5	1	7	13	1	2	2		3	13	5
Federal gov't	3	1	2	6	1			1	2	6	2
Provincial gov'ts	1	3	6	10	1	1	1		4	10	1
Associations		1	1	2					2	2	2
Consultants	1	1	1	3	1			2		3	3
Others		2		2	1	1				2	1
Summary	10	9	17	36	5	4	3	3	10	36	14
Percent	28%	25%	47%	100%	14%	11%	8%	8%	28%	100%	

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**Appendix C: Detailed findings from Associates Survey**

1. To what extent has MEND provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock?

#	Response
1	Definitive prediction for reactive tailings and waste rock is still a problem, but MEND has increased our understanding of the factors that can affect ARD and what can be done to limit ARD as a consequence.
2	They have been very useful within a North American context in providing clear and comprehensive set of reported experiments and reviews. They need to now start to produce practical Codes of Practice that can be adopted within a legal framework.
3	MEND has, over the years, provided current information via reports about prediction testing and modelling as well as techniques for waste management. Thanks to MEND, I've been able to stay abreast of advances in these areas. I also have circulated MEND reports to staff actively engaged in mine permitting.
4	MEND has provided good scientific and technical methodologies for prediction and early warning. However, as AMD is a long-term problem, the full benefits have not been seen in the project life.
5	Progress re prediction has been less than I would have guessed (predicted?) back when MEND was just getting started. Some progress has been made but I certainly do not believe that MEND has <i>"provided a comprehensive scientific, technical and economic basis for the mining industry to predict long-term requirements for reactive tailings and waste rock."</i> Field validation studies, tied to acid avoidance and alternative overburden analysis methodologies, would be useful, and could have been accomplished.
6	To a very large extent.

- 
2. What has been MEND's contribution to reducing the harmful impacts on the environment of acid mine drainage?

#	Response
1	The control and treatment of ARD has advanced significantly due to the effects of MEND. Technically it is possible to effectively eliminate the harmful impacts, but the economics are not always acceptable.
2	Poor.
3	It's hard to quantify MEND's contribution to reducing harmful impacts from ARD other than to say that ARD potential is now evaluated early on for proposed mines. Luckily, few of our modern mines have had problems with ARD. Most of the serious problems occur at long abandoned mines.
4	MEND has provided evidence of success and access to expertise which has encouraged our sides to commit to ARD prevention programs and capital works ? leading to considerable AMD reduction.
5	I believe MEND's efforts in this area have been more fruitful, and have greatly contributed to the knowledge base of key practitioners, which in turn has improved overall water quality.
6	Better awareness of the problems. Development of new solutions.

3. Has the design and delivery of MEND influenced its performance? What are the lessons learned?

	<b>Response</b>
1	1. ?The industry/government cooperation has been very useful and progressive. 2. ?The control over projects, research and expenditures kept efforts focused.
2	Unknown; only know the organization through its publications and very informal contact.
3	Although I did not attend most of the meetings, during the meeting I did attend, I was impressed by the rapport between the Canadian mining industry and Canadian regulators in trying to solve the multitude of problems inherent to ARD.
4	MEND has performed well. Its design as an open collaboration has been excellent. This openness and the secretariat staff have allowed people to obtain benefit from the expertise with minimal effort.
5	Site-specific applications have been fostered by the cooperation inherent in MEND. Industry had incentives to sponsor and conduct research, and did so, improving their in-house knowledge base and reducing their water treatment costs.
6	Much can be done when many work to attain a common goal.

4. Has MEND influenced the image and credibility of the mining industry regarding protection of the environment? In what manner and to what extent has MEND contributed to enhancing Canadian leadership internationally in the science and technology of the prevention of acid mine drainage?

	<b>Response</b>
1	1. Image and credibility for the mining industry: I think that MEND has improved the industry's image regarding environmental protection, but probably only to itself and government. Public information and public consultation was very limited. I think that it also served to bring the industry together for a more common and consistent approach to environmental issues. 2. Re international perspective: I don't know.
2	MEND has an international reputation which is only now being able to take off. They have been very proactive in looking for researchers in the area and making contact. Through their work Canada has become the leader in R&D in the more physical-chemical processes in the field of AMD and ARD.
3	I believe MEND has helped the image and credibility of industry among non-industry participants such as myself. I think it would be safe to say that Canadian industry is leading the way in this area.
4	MEND has demonstrated Canadian expertise internationally, and provided a global clearing house for information, and a benchmark against which other countries can be measured.
5	MEND allowed Canada to assume the role of international leadership with respect to prevention of acid generation at non-coal mines, and provided a model of industry/government cooperation that has been admired worldwide. I believe that it also made the industry, as a partner, more aware of environmental protection, which in turn enhanced their image and credibility.
6	Yes: it has helped enhance both the image of the industry in the public (especially in mining areas) and that of Canadian research on the international level.

5. What should be MEND's focus until its anticipated completion in 1997?

#	Response
1	Technology transfer and concise synthesis of all that has occurred. All of the good research, new initiatives and findings must be made available to the industry, government regulators and mining consultants so that they can be applied.
2	Forming a lasting network of researchers to ensure its focused research continues in a coordinated manner.
3	Anticipating termination in 1997, MEND might consider identifying areas in need of further research. Certainly, most would agree that much work remains (e.e., managing acid-generating wastes, options for acidic pit lakes, etc.).
4	As is ? and also on ensuring it progresses to another stage.
5	Given the limited time, completion of ongoing work and technology transfer is all that MEND can focus on.
6	Pursue its effort in the application of new technologies and technology transfer.



6. Is there unfinished business or changing circumstances that would suggest a need for future phases of MEND beyond 1997?

#	Response
1	Not sure except for items already identified in question 5.
2	Tighter controls will need top level R&D to ensure the continuation of mining, and proactive remediation by industry for current and past problems.
3	Yes: as described under question 5. [e.g., managing acid-generating wastes, options for acidic pit lakes.]
4	Yes: as discussed above, ARD is a long term problem, and many solutions proposed are currently being tested over extended periods. This must continue to allow iterative improvements to be made.
5	I believe that MEND should continue. Certainly, prediction of post-reclamation water quality needs additional work. Provincial and industry data, if integrated and analyzed, should provide the framework for an extremely valuable field validation study. On a broader perspective, the almost simultaneous demise of the U.S. Bureau of Mines and MEND will leave a tremendous vacuum, and no apparent successor can be seen.
6	To make sure that there is a follow-up on large scale projects that need to be monitored and properly documented to improve our knowledge of what is happening with real situations.

7. Do you have any other comments or questions about MEND?

#	Response
1	1. I was impressed by the industry/government cooperation that I witnessed. 2. I think that bringing together the various technical committees really helped look at the issues and problems from a broad perspective.
2	I found the publications most interesting and often useful for my own area which is the environmental aspects of AMD. However, it would be a great shame if they did not now move on to produce more practical outputs such as Codes of Practice, etc.
3	As a final note, I'd like to thank the Canadian government and industry for sponsoring such a far reaching effort. I enjoyed participating and established valuable friendships with Canadian regulators and industry personnel.
4	Great work - keep doing it.
5	[None.]
6	Emphasis after 1997 should be placed upon large scale applications - monitoring and data analysis. It is a good program, with some flaws (red tape, too many committees and meetings), but it has benefited the Canadian industry.

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 Appendix D: Detailed findings from Juniors Survey

## Statistical Summary of Selected Questions:

<b>1. Are you aware of MEND?</b>	Yes	12
	No	4

<b>2. Have you participated in any MEND activities?</b>	Yes	6
	No	9
	Not sure	1

<b>4. Do you know about MEND's results?</b>	Yes	6
	No	10

<b>5. Are the results useful?</b>	Useful	7
	Not useful	0
	No response	9

<b>6. How difficult was it to find out about MEND's "outputs"?</b>	Not difficult	6
	Somewhat difficult	2
	No response	8

<b>7. Would you be interested in participating more closely in MEND's activities?</b>	Yes	5
	No	9
	Maybe	1
	Don't know	1

<b>1. Are you aware of a program operated jointly by the federal government, provincial governments and the mining industry, called the Mine Environment Neutral Drainage program, or MEND?</b>	
2	No.
6	No.
7	No.
10	No. First time had heard of it, but is new (and only temporary) in this job.
8	Yes: member of Treatment Committee.
1	Yes.
3	Yes.
4	Yes.
5	Yes.
9	Yes.
11	Yes.
12	Yes. But the company employs a knowledgeable consulting engineer, and gets information through him.
13	Yes.
14	Yes.
15	Yes.
16	Yes.

<b>2. Have you participated in any way in any MEND activities? What activities? How did you participate?</b>	
2	No.
6	No.
7	No.
9	No.
10	No.
12	No.
13	No.
14	No.
15	No.
5	Thinks so: through the Canadian Mineral Processors, the Gold Adv committee, and a NOTA committee; but doesn't know for sure.
4	Yes: workshops in Vancouver (Oct. 18/95) and Saskatoon (Jun. 8/96). Also had a project at Myra Falls.
11	Yes: read some reports, two workshops.
1	Yes. Have read some project reports.
3	Yes. One project at Island Copper; other activities in BC.
8	Yes. Presentation at UBC workshop.
16	Yes. Some time ago.

<b>3. What was the reason for this: i.e., why?, or why not?</b>	
1	Mainly in student days, also through committee work of Association Minière du Québec.
2	N/A.
3	It was an appropriate project for both MEND and the company; also knows of MEND through participation in the Monitoring Committee of the BC AMD Task Force.
4	Found the activities interesting and useful.
5	There has been no real urgency to participate.
6	No reason to.
7	N/A.
8	
9	He wasn't aware of them.
10	Never heard of MEND.
11	Both out of interest, and a need to know.
12	The company uses a consultant.
13	Had no reason to.
14	No need to.
15	No need to.
16	Not at the appropriate organizational level at the present time.

<b>4. Do you know about MEND results? How did you find out about them?</b>	
2	No.
6	No.
7	No.
9	No.
10	No.
12	No.
13	No.
14	No.
15	No.
16	Not for the past two years.
1	Yes: through reading reports, also through participation on environment committee of Association Minière du Québec.
3	Yes: through the BC AMD Task Force.
4	Yes: through attending workshops etc.
5	Yes: via NOTA.
11	Yes: carried out some research programs in 1990-91.
8	Yes.

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5. What do you think of these results? Are they useful? In what way?	
2	N/A.
6	N/A.
7	N/A.
9	N/A.
10	N/A.
12	N/A.
13	N/A.
14	N/A.
15	N/A.
1	Useful: e.g., at Louvicourt mine, the underwater disposal technique is helping to alleviate environmental problems.
4	Useful: relevant to industry; beneficial.
5	Useful: they might be applicable to the company's own sites.
8	Useful: keeps reports as references.
3	Useful. Very impressed with the results. Has about two feet of documents from MEND on bookshelf.
11	Useful. Filled with information which is not too site-specific. We are moving toward a need for permafrost information.
16	Useful. The quality was good; they are good "data bank" material.

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6. How difficult was it to find out about MEND's "outputs"? [Probe.]	
2	N/A.
6	N/A.
7	N/A.
10	N/A.
12	N/A.
13	N/A.
14	N/A.
15	N/A.
1	Not hard to find out, the committee frequently discusses them.
3	Not difficult. Is on the MEND mailing list.
4	Not hard, they are listed in all MEND publications. The secretariat is good at providing them.
8	Not difficult. Uses annual reports for reference purposes.
11	Not hard to make inquiries through contacts with knowledgeable people. Also on mailing list.
16	Not difficult. The material came through the company's environmental officer (it was a different company at that time).
5	Somewhat difficult. It would be useful to have an index available. Although the annual report is useful since it does list recent reports.
9	Somewhat difficult. Not on mailing list, but knows some people on MEND. <i>"MEND should have a secretariat which could circulate stuff."</i>

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7. Would you be interested in participating more closely in MEND's activities? Why? Why not?	
3	Don't know. Can't answer due to uncertainty in personal future circumstances.
8	Might be: due to need to close acid leach dump (but it's the only one in Canada, so might not be suitable as MEND project).
1	No: there is no AMD problem at the Joe Mann mine.
6	No: there is no AMD problem at this site. They are reprocessing tailings from earlier workings, and the rock has a high carbonate content.
7	No: there is no AMD problem at their site. He is aware of AMD, but not MEND.
10	No: there is no AMD problem in their Canadian operations.
13	No: don't have any AMD problem at Golden Bear mine.
5	No. There is no problem with AMD at this company's site, so it is not necessary to do more than maintain a watching brief.
15	No. At the Mt. Pauli mine, there is lots of carbonate in the rocks, therefore AMD is not a problem.
12	Not at this time. The company's mine is not producing as yet, but maybe in the future they might be interested.
14	Not at this time, because there is no AMD at their site.
9	Yes: would like to be on mailing list. How to find people like him: MAC and OMA, etc., should have lists of environmental managers in the various mining companies.
2	Yes. Would be interested in finding out more. Companies has responsibility for six abandoned mines. Warner Lake in particular has acid generating sulphide rock problem.
4	Yes. Compared with other government programs MEND is <i>good</i> . Industry feels sense of ownership of the program.
11	Yes. Probably yes, depending on the timing since things get busy on northern sites during the spring and summer months. Also new projects may arise.
16	Yes. Possibly: the company will be reactivating the East West Caribou mine in NB and will need to have information.

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*Appendix E: Detailed findings from Technology Transfer Survey*

<b>1. Why did you attend the workshop?</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Related to work	26	51
Involved in the MEND program	2	4
Have mines in surrounding area/seen bad effects of mine drainage	2	4
To keep up-to-date/learn more about it/get more info	19	37
Was held nearby	1	2
Out of interest	6	12
Deal with environmental issues	1	2
To meet the players/have discussions with peers	3	6
To get a better understanding of what our clients are faced with	1	2
For teaching	1	2
<b>Total</b>	<b>51</b>	<b>100%</b>

Note: Totals will equal more than 100% due to multiple responses.

<b>2. Using a 10 point scale, where 1 means very dissatisfied and 10 means very satisfied, how satisfied were you with the workshop?</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Very dissatisfied	0	0
2	1	2
3	0	0
4	0	0
5	1	2
6	2	4
7	10	20
8	25	50
9	8	16
Very satisfied	3	6
<b>Total</b>	<b>50</b>	<b>100%</b>

<b>3. To what extent did the workshop meet your expectations. Please use a 10 point scale where 1 means falls short of your expectations and 10 means exceeds your expectations.</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Falls short of your expectations	0	0
2	0	0
3	0	0
4	1	2
5	2	4
6	3	6
7	14	29
8	23	47
9	3	6
Exceeds your expectations	3	6
<b>Total</b>	<b>49</b>	<b>100%</b>

<b>4. Overall, how useful was the workshop? Was it:</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Very useful	22	43
Useful	27	53
Not very useful	2	4
Not at all useful	0	0
Don't know	0	0

<b>Total</b>	<b>51</b>	<b>100%</b>
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<b>5. Have you used anything that you learned at the workshop?</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Yes	31	61
No	20	39
<b>Total</b>	<b>51</b>	<b>100%</b>

<b>6. In what way?</b>
<b>Responses</b>
It added to my knowledge
I learned post-mining environmental concerns
Contacts - names and addresses of people
You learn what other people are doing. The information or knowledge helps me do my daily job.
When reviewing progressive rehabilitation prospects it helps to have literature and information at your fingertips to help guide you in your review and provide helpful tips on problems that can occur.
I applied the knowledge that was gained to a current project.
On a day to day basis - it's hard to really put to definitely qualify the use but it's in little day to day things.
Awareness on what the US is doing and how it could apply to our situation in Nova Scotia
Analytical work and practical application
Applying acid base accounting and mineralogy to field studies.
My knowledge of acid drainage its solution is better so I am doing a better job.

6. In what way?
Responses
Applying it in my work
A broader appreciation of how people have solved environmental problems on their sights.
I used some of the newer ideas as a recommendation to a client, with regard to a mini waste problems
For our future projects in planning, we will use some of the ideas.
In reviewing closure plans, particularly in respect to in-pit disposable of waste.
I can't give anything specific. It's been awhile and trying to decipher what I learned from that is difficult.
We have rehabilitation guide lines and we would like to insert in the guide lines the more accurate predictions procedure.
We applied some of the concepts that came from the workshops to a couple of our various facilities.
In determining impacts of existing acid mine drainage locations and broadening my understanding of mitigation measures which can be implemented and also understanding that a lot of these technologies have not been proven to be 100% effective.
We're conducting field work and we have to plan sampling of tailings and waste rock and the workshop was useful to select the protocol of sampling.
In the review of closure plans and the knowledge I acquired there, I'm able to apply it to my regular job responsibilities.
To assist in our engineering work - the modelling aspects.
I'm preparing a tutorial on the data provided by the workshop.
As a consultant I work all over the world and it helps me to do a better job.
In my work, I used some of the knowledge I learned there and I applied it.
In developing new areas of work.
In one report I wrote, I used bits and pieces for mitigation measures.
In having a better idea of what options are available and the pros and cons of each option.
For comprehension of some situations.

<b>6. In what way?</b>
<b>Responses</b>
In the research lab, we're discussing with the graduate students some of the methods outlined in the workshop.



<b>7. Have you attended workshops presented by other groups which were comparable to the MEND workshops?</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Yes	25	49
No	26	51
<b>Total</b>	<b>51</b>	<b>100%</b>

<b>8. How did the MEND workshop compare to the ones offered by other groups? Was it:</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Much better	2	8
Better	9	36
About the same	11	44
Poorer	2	8
Don't know	1	4
<b>Total</b>	<b>25</b>	<b>100%</b>

<b>9. How well do you think the MEND workshop compares with the ideal workshop? Please use a 10 point scale where 1 means not very close to the ideal and 10 means very close to the ideal.</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Not very close to the ideal	0	0
2	0	0
3	0	0
4	1	2
5	5	10
6	9	19
7	13	27
8	14	29
9	3	6
Very close to the ideal	3	6
<b>Total</b>	<b>48</b>	<b>100%</b>

<b>10. What did you like best about the MEND workshop?</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Informative	10	20
Enough time for exchange/open forum/group discussions	13	26
Location	2	4
People brought in/experts	13	26
Provided copies of the report/handouts	4	8
Topical	3	6
Good presentations	9	18
Not too many people/good size	2	4
The teaching session	1	2
Well organized	3	6
Practical cases	2	4
The range it covered	1	2
Detailed	1	2
Clear/understandable	2	4
Meeting/people	1	2
Don't know	2	4
<b>Total</b>	<b>69</b>	<b>100%</b>

Note: Totals will equal more than 100% due to multiple responses.

<b>11. And, what would you improve about the MEND workshops</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
All improvements related to presentations	25	49
All technical improvements	6	12
All other improvements	5	10
No improvements	11	22
Don't know	5	10
<b>Total</b>	<b>52</b>	<b>100%</b>

<b>12. The Mend Program ends in 1997. Is there a need for further efforts by the federal and provincial governments and the Mining Association in acid mine drainage beyond that time?</b>		
<b>Responses</b>	<b>#</b>	<b>%</b>
Yes	44	94
No	3	6
<b>Total</b>	<b>47</b>	<b>100%</b>

13. What further work and information related to acid mine drainage would be most useful to you?
Responses
To follow new developments and to develop further the work that has already started.
Manuals and training.
Remediation techniques and identifying organic chemistry of AMD.
Remediation technologies on methodologies.
Ways to model acid generating rock piles.
Sledge disposal and production of AMD from waste rock.
I would like to see its people involved in this type of work given complete courses on the biological and environmental effects on mine drainage.
The assessment or determination or application of resource recovery and making AMD profitable.
Assistance for more installation and pilot projects-technical and financial.
Results of other studies.
Anything new that can be gathered-its more important now than it ever was.
The prediction method for determining whether a site is expected to be acid generating.
Evolution in laboratory production, interpretation of results.
There are still no good models that relate flour geo-chemistry. So more funding should be given to develop models.
Research on micro-biology passive treatment.
The interface between laboratory measurements full scale applications.
Continuing interchange of this type of environmental information and problem solving.
The latest innovations. Being kept informed and having an agency such as MEND available for information of help.
Continue on with field experiences.

13. What further work and information related to acid mine drainage would be most useful to you?
Responses
Continuing up-dates on technology and case studies.
Information regarding mine rehabilitation, predictions procedures and development and more easy to operate and less expensive.
Treatment, especially biological treatment.
Concrete applications on mining sites.
Anything that can be utilized in the field. More practical application of technology.
More research towards the way of controlling the AMD.
Some further conclusions from case study work in Northern Ontario and Québec. They would be useful specifically in water and clay severed AMD situations.
There are a lot of questions we don't have answered on predictions and procedures are not clear or standardized.
Keep us abreast with improvements and developments on all aspects of AMC including predictions, prevention, control, monitoring and treatment.
Experiments should be carried out for a longer period of time. There should be a follow-up of the knowledge developed and techniques form MEND and long-term monitoring.
They need practical applications that are cost effective. They have to meet Govt regulations. That's pertaining to the industry.
To co-ordinate research for a better understanding on how to manage and control AMD.
The area of risk assessment interpretation of the current methods of assessment. There are unresolved issues and the Govt should assist in providing solutions in identifying future research needs.
Research and some workshops.
Development of new test methods. The proving of remediation alternatives and continued technical transfer.
They need to continue the work on research.
We're not directly involved in AMD but I think there is a need for it.
Taking a lot of the pilot scale work that is been developed by then to the implementation stage and the identification of practical and disable solution to AMD.

<b>13. What further work and information related to acid mine drainage would be most useful to you?</b>
<b>Responses</b>
Place more emphasis on actually helping people develop the skills required to address AMD problems.
Continue the efforts to find solutions to remediate the acid generation problem.
To prevent AMD and to find the most appropriate disposal practices to neutralize the mine tailings using new methodologies.
To pursue with the problems we've identified and keep up-dating the databases.
We need to continue the MEND concept but redefine and perhaps refocus the priority activities.
Organic covers and the benefits or disadvantages and the long term stability of the organic covers.
Co-ordinate meetings, seminars, workshops.

*Appendix F: MEND's Role in Canadian Technology Infrastructure*

Review of the literature and past practices in the analysis of the impacts of Science and Technology (S&T) show mixed results. While several significant efforts have been made in these areas, work as recent as March 1993 (see OECD National Innovation Systems, March 1993) notes that there is not a strong, consistent and widely accepted approach to the assessment of S&T impacts. Past work has often taken a relatively narrow focus on the development of private intellectual property, products and processes. Alternatively, a large body of work has been built up around the production of scientific advancement of knowledge embodied in publications. (Citation analysis, bibliometrics and citation cluster analysis have all been developed extensively in this regard.)

The reality, however, is that S&T achievements are complex in nature. For example, neither a narrow focus on proprietary products/processes, nor a concentration on publications/citations captures the contribution of a national S&T program such as MEND to technology infrastructure. Recent work by Lipsey (CIAR 1992) and by Tassef (NIST 1992) supports the earlier thesis expressed by Mowery and Rosenberg (1988) that in order to understand the contribution of S&T, especially that embodied in a program such as MEND, one must employ a broader conceptual model of S&T impacts.

Up until the mid 1980s, S&T policy analysts (and economic growth policy analysts as well) regarded the typical industrial technology as largely a private good; thus, whereas government had a major role in insuring an adequate *science base* (a public good), it assumed little responsibility for contributing to the nation's *technology base* for economic growth purposes.

Over the past eight to ten years, a conceptual model has evolved which now recognizes that the typical industrial technology has a number of distinct components; equally important, the model recognizes that several of these components have "*public good*" characteristics and therefore require government involvement.

Although debate is ongoing as to the precise characterization of these public technology goods, at least two categories have gained fairly wide acceptance - especially in North America:

- *generic technology*: the first phase of technology, ending in proof of concept (laboratory



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prototype); because the marketplace objective is still quite distant, both technical and market risk are high leading to underinvestment by individual firms. Often referred to as "*precompetitive*" technology.

- *infratechnology*: a set of technical "*tools*" that enhance the productivity of the R&D, production, and market transaction stages of economic activity; they include measurement and test methods, scientific and engineering data, physical and functional system compatibility; production and quality control techniques, etc.; because these infratechnologies must be broadly accessible and commonly used to a significant degree to be effective (i.e., as standards), industry underinvests in this category as well.

According to Tasse, "*infratechnologies*" fall into three categories:

- *scientific and engineering data* that are used for conducting R&D and controlling production (e.g., information on the acid content of water surrounding mines).
- *measurement and test methods* that are essential to conduct state-of-the-art R&D, monitor and control production, and execute market transactions (e.g., acid level monitoring systems).
- *practices and technologies* that allow various elements of the typical industrial technology to be organized and utilized efficiently (e.g., prediction models, various prevention, treatment and disposal techniques).

G. Tasse, Senior Economist of the U.S. National Institute of Standards and Technology, (NIST) has noted that both generic technologies and infratechnologies are fundamentally public goods and are used by competing firms within the same and related industries. They therefore constitute critical components of a new type of economic infrastructure; in fact, while traditional infrastructure (roads, bridges, airports, energy distribution systems, etc.) remains very important, competitive position in global markets will be influenced to a relatively greater degree over the next decade by this emerging, knowledge intensive, technology infrastructure.

The Tasse NIST model, as adapted to MEND and the Canadian economy, is shown in **Figure 6** on

the following page.

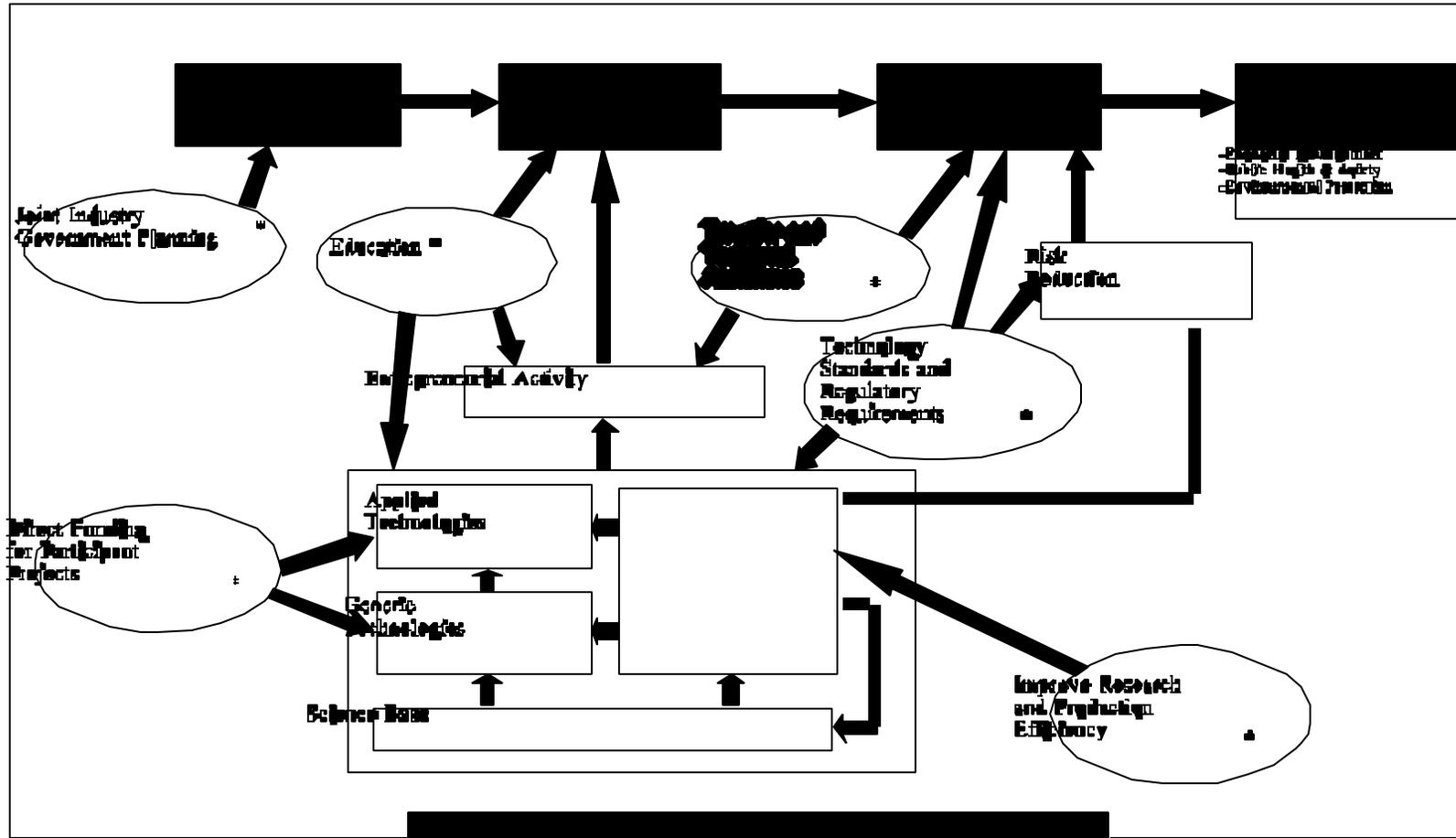
Across the top, **Figure 6** presents a highly simplified sequential model of economic development related activities:

- 1) inputs (strategic planning and investment decisions);
- 2) production and processes in key industrial sectors;
- 3) outputs of these processes in terms of market development; and
- 4) value-added results in terms of economic development (productivity, competitiveness, and wealth creation) and in terms of public health and safety and environmental protection.

Our case reviews showed that MEND played a vital role by using its network and applied research base to support joint industry-government planning to foster generic and applied technologies through MEND projects; and to develop and apply its infratechnology through testing and standards, technical transfer assistance, and education.

**The key to MEND's success has been its ability to focus multi-stakeholder collaboration across many different elements of the technology infrastructure surrounding AMD in Canada.**

**Figure 6 - Functions of the Technology Infrastructure and MEND**



Source: Young & Wilander, edited from G. Toney National Institute of Standards and Technology, U.S.A., 1991

MEND plays a significant role in each of these areas.