MEND3 Strategy Session
April 11 – 12, 2002
Ottawa, Ontario

MEND Report 8.2

Prepared for:

The Mine Environment Neutral Drainage (MEND3) Steering Committee

August, 2002

MEND3 STRATEGY SESSION
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FINAL REPORT

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August, 2002

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Stratos
strategies to sustainability

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1 EXECUTIVE SUMMARY

The MEND3 Strategy Session was held on April 11th and 12th in Ottawa, Ontario. The purpose of the session was to bring forward ideas for potential research in the area of acidic drainage[1] and related issues, and to use these recommendations to develop a focussed list of research priorities that could be presented to potential funding organizations for consideration.

Opening remarks emphasized the importance of the outcomes from the Strategy Session for the future of MEND3. The session produced a multitude of recommendations in the areas of Analysis, Modelling and Prediction; Mine Waste Management Practices; Emerging Challenges; and Post-Closure Management, and will provide the MEND3 Steering Committee with information to assist in the development of a focussed research strategy. In addition to stand-alone projects, participants also identified several cross-cutting themes.

MEND's mandate, as well as its limited resources, makes it difficult to support all research recommendations. Several key issues came out over the period of the workshop.

There is a shift from early work related to control and limitation of liabilities, to a recognition of environmental and sustainable development issues. Participants agreed that MEND should demonstrate adherence to the principles of sustainable development. This included a discussion of the environmental, social, and economic impacts of mining activities, as well as identification of key issues facing society throughout the life of a mine.

There is support and commitment from the group to undertake new research, but to do so there needs to be validation, filling of gaps, and a new philosophy related to mine closure (a legacy exists after mines close down). The group is moving in the right direction, but there should be recognition that priorities have shifted, and that the acronym no longer reflects all the activities the group is interested in. However, the international significance and connections to good mine waste management practices developed in Canada are synonymous with the MEND name.

Workshop participants recognized the value of completing a set of case studies that would build upon existing studies, and provide information about new sites. Verification of MEND developed technologies by long-term monitoring will expand the knowledge base and possibly extend application. Case studies are low-cost projects as they build on pre-existing information. There was support from several individuals to complete a case study.

An overriding and recurring recommendation of the workshop was that the MEND initiative should continue, probably with an expanded mandate beyond acidic drainage issues.

[1] The terms "acidic drainage", "Acid Mine Drainage" (AMD) and "Acid Rock Drainage" (ARD) are used interchangeably throughout the report to describe effluent generated from the oxidation of sulphide minerals

2 INTRODUCTION AND BACKGROUND INFORMATION

The workshop began with Introductory Remarks, followed by expected outcomes from the workshop and a discussion of the workshop objectives.

2.1 INTRODUCTORY REMARKS (Made by Richard Tobin, Director General, Mineral Technology Branch, Natural Resources Canada)

The future of MEND will depend greatly on the outcomes of the next two days. The number of participants at this Strategy Session demonstrates the continued importance of research in acidic drainage and related issues. The MEND initiative is a recognized model of cooperation among the Canadian mining industry, federal and provincial governments and non-government organizations in technology developments.

MEND demonstrates the benefits of multi-stakeholder involvement and collaboration, with the MEND partners operating in an environment where information is freely and openly shared, allowing the research community to build upon the work of partner organizations, as well as provide input to more comprehensive research programs and activities. A commitment to continuously improving performance requires an investment in research to develop solutions to environmental issues and challenges. Over the past 12 years partners in MEND have made major investments in technology to meet environmental, social and economic targets.

The MEND program is fully supported by the Government of Canada, which is working with the mining industry to ensure mining resources are managed in a sustainable manner. Natural Resources Canada's Sustainable Development Strategy is guiding research and technology transfer, and the department continues to coordinate research and disseminate knowledge (e.g. the MEND Manual for acidic drainage). More research is needed to reach the goals outlined in the Sustainable Development Strategy; the outcomes from this Strategy Session are important for the future of MEND.

Canada's Innovation Strategy – a new initiative designed, in part, to encourage the development of new approaches to environmental issues – will benefit from the contributions of MEND. MEND participants are encouraged to be involved in the consultation process over the next year to contribute new ideas and concepts.

2.2 INTRODUCTORY REMARKS (Made by Elizabeth Gardiner, Vice-President – Technical Affairs, The Mining Association of Canada)

In December 2000, the MEND 2000 initiative, the three-year successor to the nine-year MEND program, wrapped up its mandate. MEND 2000 accomplished several important things, including promoting information and technology transfer, monitoring the results of MEND technologies, providing essential multi-stakeholder linkages, and enhancing communications with international government and industry organizations. Under MEND 2000, a web site was created and the six-volume MEND Manual was completed.

Despite the tremendous progress made by MEND and MEND 2000, ARD remains the most significant environmental issue facing the mining industry, governments and the public, with potential liability reaching hundreds of millions of dollars. For this reason, the MEND3 program was launched in early 2001, in response to recommendations for a renewed research program. MEND3's chief objective is to foster and coordinate environmental research, development and demonstration, focusing on technologies that meet Canadian needs, within an international context.

To help more clearly define these needs and to lay the groundwork for a potential MEND3 research program, SRK Consulting and SENES prepared a report for the MEND3 Steering Committee that identified past and present ongoing research, gaps in ARD research and technology in Canada, opportunities to advance ARD knowledge, and key areas for future research and priority projects.

This report will form a major spring board for discussion at this two-day “think tank”. We have called this workshop a “strategy session” and that is why we are here. We need to come up with a strategy for the future of MEND. There may not be a future, and that is certainly an option. But essentially, this is an opportunity, with so many interested people together in one room, to help determine once and for all, a future course of action for this initiative. If we miss this opportunity, it may never return.

Many would like to see MEND continue and flourish with an expanded mandate, many would like to see its name change, many would like to narrow its mandate, some may wish to terminate the program altogether. Those to whom MEND is important, appreciate the value of this uniquely Canadian partnership beyond that of just research or technology transfer, while at the same time recognizing the current challenges posed by economic and resource constraints. Over these two days, we have some significant issues to consider, and some important decisions and recommendations to make. And, after all the talk is over, it will be time for action.

2.3 PURPOSE OF THE STRATEGY SESSION (Made by Patricia Hayes, Facilitator, Stratos)

The purpose of the Strategy Session is to build a research strategy based on the ideas that emerge from this workshop. The MEND3 Steering Committee will be looking for proposals with clear deliverables, concrete timelines and a funding strategy. The Committee will review all recommendations made at the workshop, and will develop a final list of priority recommendations that will be distributed to all relevant stakeholders.

Through development of a possible focussed research strategy, the program aims to maintain Canada’s reputation as a leader in the field of acidic drainage and related issues.

2.4 METHODOLOGY AND PROCEDURES

All participants at the workshop were invited to contribute research recommendations or topics. The workshop served to streamline the review process by providing the Steering Committee with a shortened list of quality proposals that emerged from the breakout sessions. Recommendations were submitted in relation to four themes:

1. Analysis, Modelling and Prediction
2. Mine Waste Management Practices
3. Emerging Challenges
4. Post-closure Management

Workshop participants were separated into five breakout groups. The composition of each group was pre-determined to ensure representation from all key interest groups. During each breakout session, group members were asked to recommend research priorities relevant to the four themes. Each breakout group developed a final list of six recommendations related to: (a) Themes 1 and 2; and, (b) Themes 3 and 4, for a total of 12 recommendations per group. The selection of recommendations was based on a set of criteria (Appendix C), which the group used as a basic filter to select, discuss and assess research priorities. The examination criteria were:

1. Relevance
2. Defined short- and long-term deliverables
3. Practicality, clarity and focus
4. Added value
5. Funding and partnership opportunities
6. Benefits

Each set of six recommendations was presented in plenary for further discussion and aggregated where appropriate. The final list of research recommendations was presented to the workshop participants and will be further reviewed by the MEND3 Steering Committee.

2.5 REVIEW OF GAP ANALYSIS REPORT
(Presented by Stephen Day, Principal Geochemist, SRK Consulting and David Orava, Senior Mining Engineer, SENES Consultants Ltd.)

To focus discussion during the workshop, the authors of a Gap Analysis Report provided a summary of the key findings. The purpose of the report was to identify opportunities for research advancement, and to prioritize current and future research endeavours. Information was collected from a questionnaire, three workshops, and follow-up phone calls.

Results from the questionnaire suggested that the largest research gaps existed around the behaviour of underground mines, waste blending, novel covers, passive treatment systems, permafrost, open pits, and waste rock geochemical modelling. Some of the most effective technologies included conventional treatment, HDS treatment processes, chemical analysis, water covers for unoxidized tailings, and tailings and rock segregation methods.

The report also identified key challenges to research: commodity prices are at sustained historical lows; awareness of ARD is growing (causing an increased demand for information from the public); there is greater concern over low level cumulative effects; deficit slashing by governments continue; and, there is a growing need to link ARD to broader issues.

Three primary research priorities were identified in the report:

1. Prediction (underground and open pit mines, waste rock)
2. Control/Prevention (blending, permafrost, novel covers)
3. Treatment (passive systems)

The response to the report was positive, and led to a discussion of the following:

- There is a need to establish a definition of "long term" as it relates to monitoring. Some understand it to represent a number of years, decades or centuries. Need to link "long term" with technology needs and to establish a rationale for the time frames used.
- The public does not have access to information that explains technology at a level that is broadly understood. At the same time, experts are expanding the scope and complexity of issues related to acidic drainage and the gap in public understanding continues to grow. Need to communicate openly and effectively on these issues.
- The Gap Analysis provided generalized results – there is concern that the differences between eastern and western regions have been missed because of this (e.g. the greatest issues in the west relate to the design for future closure, whereas as central and eastern regions are dealing with mines that have already been closed).
- The effects of climate change should be considered in the planning stages and in environmental impact assessments.
- There is a difference between reduction in liabilities and reduction of adverse effects related to acidic drainage. If the goal were to reduce liabilities facing the private and public sectors, then the focus of the workshop should be on assessing the options that would limit financial liabilities during the life of the mine. If the goal were to reduce adverse effects, then the workshop should focus on research proposals that would produce the greatest environmental, social, and economic returns.
- Integrated design in mining will be an important feature. Need to include all the stakeholders in the design.

2.6 CURRENT RESEARCH INITIATIVES

Overview presentations of current research initiatives were provided by representatives from the following organizations: the International Network for Acid Prevention (INAP); the research partnership program between the Natural Sciences and Engineering Research Council of Canada (NSERC), École Polytechnique de Montréal, and the Université du Québec en Abitibi-Témiscamingue (Industrial NSERC-Polytechnique-UQAT Chair); the Acid Drainage Technology Initiative (ADTI); and the Canada Centre for Mineral and Energy Technology (NRCan/CANMET). The following are summaries of the presentations.

INAP Update (presented by Mike Aziz, Manager, Equity Silver Operations, Placer Dome)
The International Network for Acid Prevention (INAP) is an international, industry-led initiative formed to promote the management of sulphidic mine materials and the prevention and control of acidic drainage. Key features of the initiative include web-based information sharing, technical networks and panels, and shared research and development of technology. INAP supports regional organizations (e.g. MEND, ADTI) through joint initiatives, attempts to reduce duplication of research efforts, and leverages funds to complete larger projects. The group also holds meetings with regional organizations to investigate working relationships and facilitate networking. Brokered research projects include, among others, work related to co-disposal, waste rock characterization, passivation of ARD using permanganate, and long-term performance of dry covers. Future projects involve efforts to create a world-wide ARD Guide.

Industrial NSERC-Polytechnique-UQAT Chair (presented by Michel Julien, Professeur, École Polytechnique de Montréal)
The project is primarily funded by NSERC (with additional funding from industry, consulting firms and the provincial government), and is a collaborative effort between École Polytechnique (Montréal) and the Université du Québec en Abitibi-Témiscamingue (UQAT – Rouyn-Noranda). The work, which focuses on the environment and mine waste management, aims to develop geo-environmental tools and techniques for integrated management of solid and liquid mining wastes (e.g. waste rock, tailings, sludge from treatment plants). The project also seeks to develop scientific specialists and provide professional training in the area of environment and mine waste management.

There are two main projects underway: (1) integrated liquid and solid waste management during operation; and, (2) reclamation of mining sites with acidic drainage problems. The projects have been developed using the natural strengths and interests of the group, by involving industrial partners to identify specific issues of importance, and by reviewing the current state of knowledge to define promising research avenues. The current operating budget is $1 million/year for five years.

ADTI Update (presented by Dirk Van Zyl, Director, Mining Life-Cycle Center, University of Nevada)
The Acid Drainage Technology Initiative (ADTI) includes stakeholders from the coal mining sector (CMS) as well as the metal mining sector (MMS). ADTI-MMS aims to promote scientifically sound mineral development that minimizes adverse impacts on water and maximizes beneficial post-mining land uses. ADTI's mission is to manage mine waste and related metallurgical materials, and to promote understanding of environmentally sound methods and technology. New initiatives include the Rocky Mountain Region Hazardous Substance Research Center (5-year program), as well as an expanded web site that includes workbooks, videos and databases (GIS and technology database).

CANMET Research Initiatives (presented by Janice Zinck, Program Manager, Mine Waste Management, Natural Resources Canada)

The Canada Centre for Mineral and Energy Technology (CANMET) has several ongoing research projects that are relevant to the MEND mandate. Research is being conducted in the area of: water cover technologies; submarine tailings disposal; biotechnology; chemical treatment; waste disposal; reclamation; sludge stability/disposal; and, metal leaching in neutral drainage. CANMET is also involved in methods development (e.g. surrogate ARD indicators and diffusion gradients in thin films).

2.7 POTENTIAL RESEARCH INITIATIVES

Representatives from Beak International and the BC Ministry of Energy and Mines provided examples of potential research. The following are summaries of the presentations.

Metal Leaching at Neutral pH; Still Under-Rated (presented by Ron Nicholson, Senior Scientist and Principal, Beak International Inc.)

Beak International is researching the effects of metal leaching at neutral pH. Some metals are potentially problematic at neutral pH: an increase in nickel concentration, for example, causes a lower pH reading, and can have a significant impact on a small watershed. It has also been discovered that up to 20% of arsenic is leachable, causing concerns over the quality of the receiving environment. Key issues that Beak International Inc. has identified are the lack of a consistent methodology or protocol, differences in interpretation and assessment of results, and the failure to integrate geochemical results with site-specific conditions. Future needs include the development of consistent methodologies, documentation of tests and interpretations, modelling approaches that will satisfy reviewers, and formal risk assessment protocols.

Metal Leaching and ARD Research Needs (presented by Bill Price, Senior Reclamation Agrologist, Mines Branch, BC Ministry of Energy and Mines)

The BC Ministry of Energy and Mines is reviewing metal leaching and acid rock drainage research needs. BC has recognized that there is still considerable uncertainty about basic processes (e.g. mitigation requirements), and that current mitigation measures are not designed and operated in a manner that will allow them to perform indefinitely. Consideration of long-term site performance is important as the costs associated with cover repair and use of lime can be substantial. Furthermore, there are more than 60 mines in British Columbia with the potential for metal leaching/acid rock drainage.

Potential new tools include: blending with non-PAG (potentially acid-generating) materials to dispose of a smaller amount of PAG waste rock, as well as the use/construction of wetlands to treat neutral pH seeps. The BC Ministry of Energy and Mines is looking for research proposals that provide an in-depth description of the research methods, time lines, short and long-term deliverables, costs of the study, and any partnership opportunities. Research proposals should also clearly identify positive and negative effects (e.g. impacts on environmental effects, costs and long-term risks).

2.8 NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL (NSERC) FUNDING OPPORTUNITIES (presented by Theresa Anderson, Program Officer, University-Industry Projects, NSERC)

NSERC Research Partnership Programs are typically directed towards university researchers and industry. Individuals and organizations present at this workshop have received funding for over 50 projects, making NSERC a significant contributor to acidic drainage research programs. NSERC is Canada's largest university research funding body, and focuses on natural sciences and engineering. Over $615 million per year has been invested in university research, and there are currently 649 partner firms (representing over 60% of Canada's Top 50 R&D firms). Partner firms (typically science or technology based firms) determine a research topic, select a research partner, and negotiate the terms of an agreement. The company will participate in formulating the project, contribute 50% in cash or in-kind support, and collaborate with university participants throughout the project. Approval rates for collaborate research and development projects are approximately 80%.

3 THEMES 1 AND 2: ANALYSIS, MODELLING AND PREDICTION; AND MINE WASTE MANAGEMENT PRACTICES

Priority research areas related to Analysis Modelling and Prediction and Mine Waste Management were discussed in a breakout session. The different groups brought the following research proposals to plenary. A complete list of all research ideas discussed in the breakout sessions is included in the Appendices.

YELLOW

1. Develop or test remote sensing monitoring tools for sites including continuous feed leading to triggers
2. Review selected sites for the predicted performance (including costs of the full mine life cycle)
3. Re-assessment of prediction tools with a focus on tools for the early screening of the acid potential of properties
4. Develop life cycle geo-environmental ore deposit models
5. Investigate the geochemical stability of paste backfill for underground operations in the long term

BLUE

1. Develop improved prediction models
2. Develop standards for environmental risk assessment
3. Conduct integrated research related to mine waste management, planning, financial, environmental effects
4. Research potential uses and effects of permafrost
5. Conduct further research related to biological treatment (passive) systems
6. Conduct additional research on the use/benefits of novel covers

RED

1. Develop/review Post-Audit evaluation models
2. Develop/identify indicators of early sulphide oxidation
3. Conduct research into the behaviour of metal loadings from waste rock
4. Conduct further research related to passive treatment
5. Determine the ecological impacts of water covers
6. Review practices/special requirements related to mine waste management in cold climate conditions

ORANGE

1. Follow-up on model predictions (reality check) in field. Focus on specific uncertainties for fill-in research (how well have the models predicted what has happened in reality; verification would focus on particular uncertainties)
2. Define biological influence on metal mobilization
3. Collect fundamental data on critical secondary solids (controlling metals)
4. Update BAT/BMP Guidelines by metal sector (in the context of Canada and MEND)
5. Assess disposal of sludge in underground mines
6. Determine the stability of mine fill

GREEN

1. Research dry covers: from design to natural system (any alternatives?)
2. Research the implications of climate change (when preparing wet and dry covers)
3. Complete a verification/audit of existing technology (work related to monitoring facilities has been done – current technology should be reviewed)
4. Research oxidation kinetics at low temperatures (with more arctic mines being developed, combating acidic drainage and metal leaching needs to be researched in the context of cold temperatures – e.g. below 2°C)
5. Define long-term performance (perhaps a different terminology should be used)
6. Research non-acid sensitive metal leaching (best management practices?, etc.)
7. Integrate operation and closure (in terms of mine waste practices)
8. Investigate options related to pre-treatment of tailings before discharge
9. Review/determine the performance of in-pit disposal systems
10. Develop protocols for performance modelling (what information should be extracted? Perhaps done outside MEND)
11. Investigate sludge reuse options (what can be done with this material?)
12. Revisit passive treatment systems (identify under what conditions they will work)
13. Update MEND studies (verification, demonstrate performance)
14. Improve dissemination of information and communication strategies (cross-cutting theme)

4 THEMES 3 AND 4: EMERGING CHALLENGES; AND POST-CLOSURE MANAGEMENT

Priority research areas related to Emerging Challenges and Post-Closure Management were discussed in a breakout session. The following research proposals were brought to plenary. A complete list of all research ideas discussed in the breakout sessions is included in the Appendix.

YELLOW

1. Investigate mobility of arsenic, selenium, antimony, molybdenum, nickel, thallium, tellurium (oxy-anions)
2. Review techniques for tailings passivation
3. Increase public awareness of ARD – prepare educational tools on ARD
4. Review chemical stability of encapsulation technologies
5. Investigate surface chemistry of sulphide minerals
6. Investigate alternative financial assurances

BLUE

1. Research the effects of re-opening mines
2. Determine cumulative effects (in pristine areas)
3. Provide and improve community support
4. Investigate productive uses of wastes
5. Identify means of managing permafrost effects in containment facilities
6. Determine the effects of climate change
7. Revisit closure cost models: this would affect the philosophy of closure and the value of closure
8. Develop case histories (this should include a discussion of a definition for long term)
9. Research finite post-closure methods technology

RED

1. Conduct further research related to TDS treatment
2. Review/develop cost-effective treatment methods for hard to treat elements (Sb, Cd, As, Se, Hg), and chemicals (thiosalts, thiocyanates), etc.
3. Develop novel milling processes to reduce environmental impacts of mine wastes, turn tailings into soil
4. Development of low cost solutions for reclamation of abandoned mines; MEND and/or other programs
5. Evaluation of ecological recovery for closed mines
6. Expand use of remote sensing tools

ORANGE
1. Develop/refine and apply optimal geochemical, ecological and geotechnical monitoring techniques for early warning for potential impacts at mine sites
2. Identify and designate MEND (and other) study sites for critical evaluation, for publicly available study
3. Create benefits (or beneficial values) from waste and mine facilities at end-of-life
4. Engineer natural analogues to mitigate impacts and retain contaminants
5. Develop alternative standards and procedures for assessing progressive closure versus end of life
6. Research groundwater issues

GREEN
1. Research hydrogeotechnical behaviour of waste rock piles
2. Research metal leaching in non-acidic conditions (geochemical perspective and physical aspects)
3. Conduct/host workshops (technology transfer for specific tools; community focussed – building technical capacity at community level)
4. Develop improved monitoring methodologies
5. Research benefits/uses of co-disposal
6. Research benefits/costs of dry stack tailings (global literature review of advantages and disadvantages in a Canadian context)

5 SUMMARY OF RECOMMENDATIONS

A focussed list of research proposals emerging from the breakout sessions were presented in plenary. Recommended research activities were grouped and categorized as appropriate, and any linkages across themes were identified. An open discussion followed the categorization process.

5.1 CROSS-CUTTING ISSUES

One breakout group provided a list of cross-cutting issues. The list included:

- Risk assessment (including social, environmental, economic dimensions)
- Cost-effectiveness
- Communication/Technology transfer
- Documentation
- ISO/EMS/BMP (note from participant: ISO may not be a cross-cutting theme)
- Case studies on already accepted technologies

5.2 GROUPING OF RESEARCH RECOMMENDATIONS

After all research recommendations had been presented in plenary the research proposals were examined for possible clustering according to subject area. Titles were subsequently added for the clustered projects by the MEND Secretariat. Many of the projects were stand-alone and were listed as single recommendations.

THEME 1: ANALYSIS, MODELLING AND PREDICTION

Clustered Recommendations

Verification of Models

1. Review of selected sites for predicted performance
2. Post-audit evaluation models
3. Follow-up on model predictions in field (verification)
4. Improved prediction models
5. Verification/audit of existing technology

Early Prediction

6. Indicators of early sulphide oxidation
7. Reassessment of prediction tools for early screening

Single Recommendations

8. Define biological influence on metal mobilization
9. Practitioner's guide (Standards for environmental risk assessment)
10. Metal loadings from waste rock
11. Remote sensing monitoring tools
12. Model refinement – environmental data

THEME 2: MINE WASTE MANAGEMENT PRACTICES

Clustered Recommendations

Passive Treatment

1. Passive treatment
2. Biological treatment (passive)
3. Wetlands (revisit the use of)

Cold Temperature Effects

4. Oxidation Kinetics
5. Permafrost
6. Mine waste management in cold weather

Guidelines

7. Best Available Technology (BAT) and Best Management Practices (BMP) – Guideline update
8. Mine waste management- Financial model and environmental effects

Sludge Management

9. Sludge disposal (underground, underwater)
10. Sludge options (i.e. metal recovery)

Reactive Paste Backfill

11. Geochemical stability of paste backfill
12. Oxidized/reacted backfill

Single Recommendations

13. Pretreatment of tailings
14. Ecological impacts of water covers
15. Novel covers
16. Geoenvironmental ore deposit model

THEME 3: EMERGING CHALLENGES

Clustered Recommendations

Technology Transfer

1. Public awareness of acidic drainage
2. Workshops
3. Community support

Metal Leaching

4. Mobility of As, Se, Sb, Mo, Ni, Te, Tl
5. Metal leaching in non-acidic conditions
6. Cost effective treatment of hard to treat elements

Emerging Technologies

7. Novel milling processes to reduce environmental impacts
8. Techniques for tailings passivation
9. Engineering of natural analogues
10. Productive use of waste

Single Recommendations

11. Groundwater as a resource
12. Alternative financial assurance
13. Hydrogeotechnical behaviour of waste rock piles
14. Effects of re-opening
15. Cumulative effects on environment (e.g. metal availability, speciation)
16. Surface chemistry of sulphides
17. TDS treatment
18. Review of waste management practices
19. Chemical stability of encapsulation technology (capping)

THEME 4: POST-CLOSURE MANAGEMENT

Clustered Recommendations

Closure Management

1. Develop alternative standards and procedures for assessing progressive vs end of life reclamation
2. Revisit closure cost models
3. Finite closures

Monitoring

4. Develop, refine and apply optimal monitoring techniques
5. Remote sensing
6. Monitoring methodology

Technology Transfer

7. Identify and designate MEND and other potential mine sites
8. Case histories

Single Recommendations

9. Develop low cost solutions for abandoned mines
10. Evaluation of ecological recovery for closed mines

6 FINAL DISCUSSION

After the research proposals and recommendations had been presented and categorized, workshop participants were presented with a series of questions to guide discussion. A wide range of responses and ideas were elicited.

6.1 GUIDED DISCUSSION OF SELECTED RESEARCH PRIORITIES

1. What will these projects accomplish? If implemented, where would the biggest change be?

- Uncertainties would be reduced, and a precautionary/conservative approach could be taken if necessary
- The public would have a greater understanding and acceptance
- The ultimate goal would be to erase the mine footprint
- The industry would be better prepared to deal with new and emerging issues in the future.

2. Is this list of research proposals and recommendations (covered in breakout session and SRK/SENES report) going to meet the needs of the group?

Participants did not comment overall, but one noted that pilot scale trials should be used first, then move on to full-scale trials (e.g. co-disposal).

3. How well positioned is MEND to deliver on a strategy that supports these research initiatives?

- It was suggested that the group look at performance of the last few years and determine if the research has provided the industry and the public with effective tools. If the answer is yes, MEND should continue with its current mandate and activities.
- To be able to deliver, MEND needs a consistent and secure source of funding. As yet, however, it is unclear if MEND will have access to sufficient resources.
- The three-year timeframe for which the projects are being developed appears prohibitive. A more realistic time frame would be five years.
- To streamline the funding process and assist the group in acquiring funds from external sources, a focussed list of research priorities should be established (purpose of this meeting).
- Historically, MEND has been successful, but there are concerns that the low hanging fruit has already been picked. MEND3 is looking at longer term and more complex issues; projects are very site specific, and perhaps academia is better positioned to conduct this research.
- When determining which project(s) should be selected for funding, there needs to be consideration of the project's return on investment (often a key funding criteria).
- Addressing issues of ARD in the 1980s and 90s was compelling for society and for mining companies holding liability. For some, the current list of projects does not demonstrate equally compelling reasons for conducting the research, with the exception of a few research priorities that MEND will be well positioned to do. Projects should be tailored towards the need for research where other organizations are not providing sufficient information.

4. How would the group characterize current research needs?

- Documentation and assessment of what has been achieved in previous activities should be a priority. This should be a verification and assessment process where the actual results are compared to the predicted results. As a neutral body, MEND is well positioned to complete this work.
- Previous work does not necessarily represent the "lowest hanging fruit." The work that has been done earlier was not necessarily easier, but MEND was in a better position at the time to deal with those issues. The proposed research appears to be similar to what has been done in the past, but has perhaps a slightly different focus.
- Previous research looked at the bigger picture, but current research is more focussed in order to fill in the details that were not reviewed in the earlier stages.
- The group should exercise caution in drawing negative conclusions, but at the same time should not ignore the results of experiments where the researchers did not get the results they anticipated. These findings could still be important to the overall process, and it is possible that improvements in sampling, analysis and technology could alter past results.
- Current issues are more long term and deal with mine closure issues. The issues are more complex, and relate directly to the concept of sustainable development, of which environment and closure are key components. MEND3 should be packaged in a way that enforces sustainable

development and sustainable business decisions, as this will attract the attention of CEOs. Current research projects, however, do not necessarily demonstrate a business case beyond the financial benefits of obtaining information.

- MEND was originally established to deal with liabilities, but the shift is now towards mine closure and long-term issues. It should be noted, however, that all closure and post-closure issues are about liabilities as they apply to social, environmental and economic issues. These are elements that MEND will have to address.
- Different stakeholders will have a different idea of which research priorities are important. The challenge is to find a subset of projects that all stakeholders can support.

6.2 Seeking Support for Proposed Research

An open discussion produced the following comments:

- Good thoughts have been presented at this workshop. MEND3 should sort these projects according to identified priorities; these priorities should be identified first (either within the MEND3 Steering Committee or externally).
- The MEND3 Steering Committee should develop the research priorities and strategy, without going to a vetting process outside of the Committee. An external review, unless balanced, could result in an unbalanced representation of research needs.
- How potential partners and funding bodies will be approached needs to be determined. MEND lobbyists should include industry (e.g. MAC) and government groups, along with ongoing advice from academia, non-government organizations and consulting groups. As a group that represents multi-stakeholder interests, the MEND3 Steering Committee should solicit input from all disciplines and organizations.
- Since industry and government are funding the program, they should be able to demonstrate how they will benefit from this work. The MEND3 Steering Committee appears well positioned to present this viewpoint.
- When considering costs and benefits, social and environmental considerations should be included. A dollar value for MEND should include social and environmental risk, and should provide an estimation of the benefits to all members of society as a result of the work.
- Sustainable development must be incorporated into the strategy emerging from this workshop. The group must demonstrate that they are working toward sustainable development – especially in light of The Mining Association of Canada's "Towards Sustainable Mining Draft Guiding Principles" and NRCan's Sustainable Development Strategy.

6.3 Needs Assessment

Participants were asked to comment on areas where MEND could be stronger and more robust. The discussion resulted in the following comments:

- MEND needs more financial resources as well as political will.

- Perceptions of "benefit" vary between the groups involved in MEND. A judgment of "needs" determines the level of political will, and is influenced by timelines (short-term benefits and long-term benefits often receive different levels of support).
- MEND perhaps needs a new name to reflect changing needs. Although the program formerly focussed on acidic drainage, the focus is now expanding to different research areas.
- It is unclear how much work can be done under the current MEND mandate. There should be a commitment from government to set up an infrastructure and support system. It is possible that the original work of MEND is over, and that a new infrastructure should be established to keep MEND going forward under a different structure.
- It should be noted that the original MEND program had 4 technical committees, but is now down to 1.2 person year. MEND has been responding to changes throughout its duration, and will continue to do so in the future.

6.4 CASE STUDIES

- Some thought needs to be given to technology transfer and communication aspects. Case studies might be one way of bringing together and benefiting all members of the group. Case studies have a significant level of value as a unifying approach, and are also capable of developing and presenting the business case.
- INAP adopted the idea of creating case studies in the past, but were unable to complete the work as companies did not want to discuss what was happening at their sites due to fears over legal liability. MEND files could, however, be reviewed if firms agree to cooperate and contribute. There is also added value in organizing and interpreting what already exists.
- A starting point for the case studies could be a review of existing papers written by consultants. The MEND web site currently has some of these papers online, and although they might not meet the exact focus of the group, they could provide a foundation for new work. The studies could be added to and expanded, and a framework could be developed to guide preparation of new case studies. With appropriate guidance, and as a cost saving measure, students could gather basic information from existing documents to identify areas where additional research is required.
- Based on the limited resources available, case studies appear to be a viable option. The greatest challenge will be in finding volunteers who are willing to provide information on their specific site, as concerns over liability and might prevent participants from disclosing information

Recommendations for verification and validation of previous work were made during the workshop. To incorporate this idea, the case studies will be written according to a new framework that will allow for comparison between studies, as well as the identification of key issues. There is support to proceed, and the support may increase after some participants have the opportunity to consult with and seek the agreement of their colleagues or head office.

The following individuals committed to completing a case study: Craig Ford (Inmet Mining Corporation), Janet Freeth (Teck Cominco Ltd.), Mike Aziz (INAP), and Michele Coleman (NB Coal Ltd.). A representative from the NSERC process was uncertain if this type of work would qualify for funding.

6.5 NEXT STEPS

During plenary and session discussions much emphasis was placed on the following issues:

- Technological gaps,
- Mine waste practices,
- Best Achievable Technologies (BAT), and
- Public communication and awareness (capacity building).

Furthermore, several participants emphasized the equal importance of post-closure issues and the need for improved understanding of what can occur after closure as conditions change (in the long term). Integration of these issues into the research plan was recommended.

Based on the limited resources available, reporting on case studies appear to be a viable option, and was supported by the group. The greatest challenge will be in finding volunteers who are willing to provide information on their specific site, as concerns over liability could prevent participants from disclosing information.

There was a desire to attempt to seek a secure funding base from the partners for an ongoing R&D program, built around broad aims as opposed to funding on a project-by-project basis.

6.6 FINAL COMMENTS FROM MEND3 STEERING COMMITTEE

In summation, members of the MEND3 Steering Committee noted that there appears to be confidence in MEND, and that the conditions exist to move forward and seek resources and partnerships. Some of the points are as follows:

- MEND is a uniquely Canadian model of collaboration. Openness of discussion and transparency of information has allowed the program to move forward. MEND is a good "clearing house of information"
- Continuity and accessibility of Secretariat has allowed MEND to be an "information base" for ARD
- It was noted that MEND3 should continue fundamental research. Costs associated with research can be high, but the investment often produces long-term benefits. The case studies should not be considered an alternative to research.
- It is recognized that an overlap between membership on the MEND committee and the abandoned mine committee exists. Interests also overlap, and there are opportunities for collaborative work and linkages between the two groups. MEND and the Orphaned/Abandoned Mines Initiative were encouraged to discuss common issues.
- Sustainable development is integral to MEND activities, and there is no end to these efforts (work will be ongoing). Future work should be conducted through the lens of sustainable development.

CLOSING REMARKS

(**Made by Gilles Tremblay, MEND Secretariat)**

Thank you to all the participants who joined us over the last two days for their time and contribution. The MEND name has brought forward a positive image, and the program is recognized as a leader in acidic drainage research. The multi-stakeholder approach is successful, and the networks that have formed have strengthened the program. A research plan will be put together by the MEND3 Steering Committee based on the discussions of the last two day, and funding will be sought for 2003.

APPENDIX A: LIST OF REGISTRANTS (BY SECTOR)

ACADEMIA

1. Heather Jamieson - Associate Professor, Queen's University, Dept. Geological Sciences and Geological Engineering
2. Michel R. Julien - Professeur, École Polytechnique de Montréal
3. Leslie Smith - Professor, University of British Columbia, Dept. of Earth and Ocean Sciences
4. Jim Finch - Professor, McGill University, Dept. of Mining, Metals and Materials Engineering
5. Barbara L. Sherriff - Professor, University of Manitoba;
6. Lionel Catalan - Associate Professor, Canada Research Chair, Lakehead University
7. Ernest K. Yanful - Professor, University of Western Ontario, Dept. of Civil and Environmental Engineering
8. Graeme Spiers - Laurentian University, MIRARCO
9. David Blowes - Professor, University of Waterloo
10. Denis Bois - Directeur URSTM, Université du Québec en Abitibi-Témiscamingue
11. Ziad Saghir - Professor, Ryerson University; Dept. of Mechanical Engineering
12. Dirk van Zyl - Director, Mining Life-Cycle Center, University of Nevada, Mackay School of Mines

CONSULTANCIES

13. Claude Bedard - Vice-president, Journeaux Bedard & Associates, Inc
14. Bernard Aubé - Water Treatment Specialist, EnvirAubé
15. André Sobolewski - President, Microbial Technologies, Inc,
16. Wade Stogran - Senior Project Manager, Lakefield Research Laboratory
17. Steve Reitzel - Environmental Engineer, AMEC Earth and Environmental
18. Stephen Day - Principal Geochemist, SRK Consulting
19. Ken DeVos - Golder Associates
20. Steven Aiken - Project Manager, Knight Piésold Consulting
21. David A. Orava - Senior Mining Engineer, SENES Consultants Limited
22. Mike O'Kane - Senior Geotechnical Engineer, O'Kane Consultants Inc.
23. Ronald Nicholson - Senior Scientist and Principal, Beak International
24. Gail Amyot - G.E.A. inc
25. James Higgins - Manager, Ecological Engineering & Special Projects, Jacques Whitford Environment Ltd.
26. Igor Holubec - Consulting Engineer, I. Holubec Consulting Inc.
27. Christopher Wren - ESG International
28. Michael Sudbury - Director, Michael P. Sudbury Consulting Services Inc.
29. Nural Kuyucak - Waste Management and Process Specialist, Golder Associates
30. Margarete Kalin - President, Boojum Research Limited

CROWN

31. Mahrez Ben Belfadhel - Specialist, Canadian Nuclear Safety Commission
32. Theresa Anderson - Program Officer, University-Industry Projects, NSERC

ENGO/NGOs

33. Catherine Coumans - MiningWatch Canada
34. Catherine Daniel - Canadian Environmental Network
35. Brennain Lloyd - Northwatch
36. Glenda Ferris - Northern Ecology Action Committee
37. Alan Penn - Science Advisor, Cree Regional Authority

FEDERAL GOVERNMENT

38. Lisa Keller - Head -Remediation, Contaminated Sites – Environment Canada
39. Tom Hynes - Deputy Director, MMSL, Natural Resources Canada
40. John Kwong - Senior Environmental Scientist, CANMET, Natural Resources Canada
41. Jim McGeer - Program Manager, Metals and the Environment, Natural Resources Canada
42. David Koren - Program Manager, Mining Effluents, MMSL, Natural Resources Canada
43. Richard Tobin – Director General, Mineral Technology Branch, Natural Resources Canada
44. Roy Sage - Director, Mining and Mineral Sciences Laboratories, Natural Resources Canada
45. Charlene Hogan - MEND Secretariat, Natural Resources Canada
46. Gilles Tremblay – MEND Secretariat, Natural Resources Canada
47. Jean-Maurice Coutu - Policy Program Officer, Environmental Science Branch, Department of Fisheries and Oceans Canada
48. Janice Zinck - Program Manager, Mine Waste Management, CANMET, Natural Resources Canada
49. Paul Rochon - Program Engineer, National Office of Pollution Prevention, Environment Canada
50. Gilles Tremblay - MEND Secretariat, Natural Resources Canada
51. Nand Davé - Research Scientist, CANMET, Natural Resources Canada
52. Chris Doiron - Senior Specialist, Standards Development, Minerals & Metals Division, Environment Canada

INDUSTRY

53. Lisa Lanteigne - Co-ordinator - Decommissioning and Reclamation, Inco Ltd.
54. Craig Ford - Director, Safety, Environmental and Community Affairs, Inmet Mining Corporation
55. Dominque Beaudry - Environmental Co-ordinator, Barrick-Bousquet
56. Jim Millard - Environmental Specialist, BHP Billiton Diamonds
57. Gord MacDonald - Environmental Advisor, Diavik Diamond Mines Inc.
58. Elizabeth Gardiner - Vice President, Technical Affairs, The Mining Association of Canada
59. Andrew Cormier - President, NB Coal Limited
60. Michele Coleman - Environmental Engineer, NB Coal Limited
61. Janet Freeth - Senior Environmental Coordinator, Teck Cominco Limited
62. Mike Aziz - Manager, Equity Silver Operations, Placer Dome Canada, Equity Division
63. Denis J. Kemp - Director, Environmental Development, Falconbridge Limited
64. Bernard Vigneault - Research Associate, Noranda Inc., Technology Centre

PROVINCIAL GOVERNMENT

65. John Robertson - Manager, Rehabilitation Inspection and Compliance, Ministry of Northern Development and Mines, Ontario
66. Christine Kaszycki - Manitoba Industry, Trade and Mines, Manitoba
67. John Griggs - Manager, Resource Approvals, New Brunswick Dept. of Natural Resources and Energy
68. Claude Gignac - Chimiste, Ministère de l'environnment du Québec
69. Louis Bienvenu - ingénieur, Ministère des ressources naturelles du Québec
70. Bill Price - Senior Reclamation Agrologist, Mines Branch, BC Ministry of Energy and Mines

APPENDIX B: BREAK-OUT GROUPS

RED

1. ***Facilitator*:** Janice Zinck, Program Manager, Mine Waste Management, CANMET, Natural Resources Canada
2. ***Reporter*:** Charlene Hogan, MEND Secretariat, Natural Resources Canada
3. Academia / Michel R. Julien - Professeur, Ecole Polytechnique de Montréal
4. Academia / Jim Finch - Professor, McGill University, Dept. of Mining, Metals and Materials Engineering
5. Academia / Leslie Smith - Professor, University of British Columbia, Dept. of Earth and Ocean Science
6. Consultancy / Bernard Aubé - Water Treatment Specialist, EnvirAubé
7. Consultancy / André Sobolewski - President, Microbial Technologies, Inc.
8. ENGO / Glenda Ferris - Northern Ecology Action Committee
9. Federal Government - EC / Lisa Keller - Head -Remediation, Contaminated Sites - EC
10. Federal Government- NRCan / Nand Davé - Research Scientist, CANMET, Natural Resources Canada
11. Industry / Jim Millard - Environmental Specialist, BHP Billiton Diamonds
12. Provincial Government - QC / Louis Bienvenu - ingénieur, Ministère des ressources naturelles du Québec

ORANGE

1. ***Facilitator:*** Denis Kemp, Director, Environmental Development, Falconbridge Limited
2. ***Reporter (11th)*:** Elizabeth Gardiner, Vice President, Technical Affairs, The Mining Association of Canada
3. ***Reporter (12th):*** Jim McGeer, Program Manager, Metals and the Environment, Natural Resources Canada
4. Academia / Ernest K. Yanful - Professor, University of Western Ontario, Dept. of Civil and Environmental Engineering
5. Academia / Barbara L. Sherriff - Professor, University of Manitoba
6. Consultancy / Wade Stogran - Senior Project Manager, Lakefield Research Laboratory
7. Consultancy / Ronald Nicholson - Senior Scientist and Principal, Beak International
8. Consultancy / Margarete Kalin - President, Boojum Research Limited
9. Consultancy / Steven Aiken - Project Manager, Knight Piésold Consulting
10. Consultancy / Michael Sudbury - Director, Michael P. Sudbury Consulting Services Inc.
11. ENGO / Catherine Coumans - MiningWatch Canada
12. Industry / Dominque Beaudry - Environmental Co-ordinator, Barrick-Bousquet
13. Industry / Bernard Vigneault - Research Associate, Noranda Inc., Technology Centre
14. Provincial Government - QC / Claude Gignac - Chimiste, Ministère de l'environnment du Québec

YELLOW

1. ***Facilitator***: Bill Price, Senior Reclamation Agrologist, Mines Branch, BC Ministry of Energy and Mines
2. ***Reporter:*** Mike Aziz, Manager, Equity Silver Operations, Placer Dome Canada
3. Academia / Heather Jamieson - Associate Professor, Queen's University, Dept. Geological Sciences and Geological Engineering
4. Academia / Graeme Spiers - , Laurentian University, MIRARCO
5. Consultancy / Steve Reitzel - Environmental Engineer, AMEC Earth and Environmental
6. Consultancy / Claude Bedard - Vice-president, Journeaux Bedard & Associates, Inc
7. Consultancy / Ken DeVos - Golder Associates
8. Consultancy / Christopher Wren - ESG International
9. ENGO / Brennain Lloyd - Northwatch
10. Federal Government-NRCan / John Kwong - Senior Environmental Scientist, CANMET, Natural Resources Canada

11. Federal Government - NRCan / Tom Hynes - Deputy Director, MMSL, Natural Resources Canada
12. Industry / Craig Ford - Director, Safety, Environmental and Community Affairs, Inmet Mining Corporation
13. Industry / Janet Freeth - Senior Environmental Coordinator, Teck Cominco Limited
14. Provincial Government - ON / John Robertson - Manager, Rehabilitation Inspection and Compliance, Ministry of Northern Development and Mines, Ontario

GREEN

1. ***Facilitator (11th):*** David A. Orava, Senior Mining Engineer, SENES Consultants Ltd.
2. ***Facilitator (12th) and Reporter (11th):*** Mary Jane Middelkoop, Senior Researcher, Stratos Inc.
3. ***Reporter (12th):*** Gilles Tremblay, MEND Secretariat, Natural Resources Canada
4. Academia / Denis Bois - Directeur URSTM, Université du Québec en Abitibi-Témiscamingue
5. Academia / Dirk van Zyl - Director, Mining Life-Cycle Center, University of Nevada, Mackay School of Mines (11th only)
6. Consultancy / Mike O'Kane - Senior Geotechnical Engineer, O'Kane Consultants Inc.
7. Consultancy / Nural Kuyucak - Waste Management and Process Specialist, Golder Associates
8. Consultancy / Igor Holubec - Consulting Engineer, I. Holubec Consulting Inc.
9. Crown / Mahrez Ben Belfadhel - Specialist, Canadian Nuclear Safety Commission
10. ENGO / Catherine Daniel - Canadian Environmental Network
11. Federal Government - EC / Paul Rochon - Program Engineer, National Office of Pollution Prevention – Environment Canada
12. Industry / Michele Coleman - Environmental Engineer, NB Coal Limited
13. Provincial Government - NB / John Griggs - Manager, Resource Approvals, New Brunswick Dept. of Natural Resources and Energy

BLUE

1. ***Facilitator:*** Stephen Day, Principal Geochemist, SRK Consulting
2. ***Reporter:*** David Koren, Program Manager, Mining Effluents, Mining and Mineral Sciences Laboratories, Natural Resources Canada
3. Academia / David Blowes - Professor, University of Waterloo
4. Academia / Ziad Saghir - Professor, Ryerson University; Dept. of Mechanical Engineering
5. Academia / Lionel Catalan - Associate Professor, Canada Research Chair, Lakehead University
6. Consultancy / Gail Amyot - G.E.A. inc
7. Consultancy / James Higgins - Manager, Ecological Engineering & Special Projects, Jacques Whitford Environment Ltd.
8. NGO / Alan Penn - Science Advisor, Cree Regional Authority
9. Federal Government - DFO / Jean-Maurice Coutu - Policy Program Officer, Environmental Science Branch, DFO
10. Industry / Lisa Lanteigne - Co-ordinator - Decommissioning and Reclamation, Inco Ltd.
11. Industry / Gord MacDonald - Environmental Advisor, Diavik Diamond Mines Inc.
12. Provincial Government - MB / Christine Kaszycki - Manitoba Industry, Trade and Mines

APPENDIX C: CRITERIA FOR PROJECT RECOMMENDATIONS

MEND 3 STRATEGY SESSION: RESEARCH GAPS AND OPPORTUNITIES

PROPOSED CRITERIA FOR PARTICIPANTS
TO
EXAMINE AND SELECT RESEARCH PRIORITIES

The following criteria are intended to help guide your examination and selection of research topics and priorities. The list is not exhaustive; it provides a basic filter through which you can discuss and assess the relative merits of different research opportunities from a common perspective.

A. Proposed Criteria

1. **Relevance** (specific to the new goals of the MEND3 mandate, to the needs of communities and to society as a whole)

2. **Defined Short- and Long-Term Deliverables** (results-oriented and time-bound research projects)

3. **Practicality, clarity, focus** (effectiveness in addressing goal(s), practical demonstrations of technology development, 'do-able', measurable, specific)

4. **Added Value** (extension of existing work / ideas, new initiatives that fill identified gaps, research projects which are complementary to existing research)

5. **Funding and Partnership Opportunities** (identification of potentially involved communities / partners and / or initiatives, leveraged programs)

6. **Benefits** (potential for the results of the research to benefit the greatest number of mine sites, environments and civil society as a whole)

APPENDIX D: DETAILED PROJECT DESCRIPTIONS - THEME 1

GROUP: BLUE

PROJECT TITLE: IMPROVED PREDICTION MODELLING
DETAILS:
Outcome: more reliable long term predictions
Relevance: sound decision making
Short/Long-term deliverables: methods evaluation/modelling approach
Practicality, clarify, focus: hard going at beginning, but big reward at end
Added value: yes (existing university research)
Benefits: could apply to many sites

The following projects were grouped under this Project Title:

PROJECT TITLE: Scale up project
DETAILS: Research would involve a scale up of laboratory tests to the field (i.e. real world situation). Included would be research related to:

- Methods to evaluate the validity of tests
- Scaling up kinetic tests to the field
- Long term prediction of waste rock

PROJECT TITLE: Consistency of numerical codes
DETAILS: This proposal refers to the need for consistency in the numerical codes/programs that are being used in present models. Included would be research related to:

- Benchmarking/comparison of existing models
- Standardized predictive modelling
- Accurate numerical modelling

PROJECT TITLE: Verification of Existing Prediction Models
DETAILS: Research would involve testing of these models with real data. This would provide the users with some degree of confidence in the predictions that are obtained. Included would be research related to:

- Verification of prediction modelling
- Timeliness/confidence of prediction modelling
- Improve certainty of waste rock modelling

PROJECT TITLE: Standards for Environmental Risk Assessments – Practitioner's Guide
DETAILS: In addition to developing standards, this research would involve the following activities:

- Linking risk assessment and prediction
- Application of risk management to mining

Outcome: Practitioner's Guide
Relevance: meets goals of sustainable development
Short/Long-term deliverables: practitioner's guide
Added value: INAP
Funding/Partnership Opportunities: INAP
Benefits: allow for reaching closure

PROJECT TITLE: Standardized Biological Methods
DETAILS: In addition to developing standardized methods, research would involve the following activities:

- Metal speciation – biological availability and routine analyses; a continuing challenge
- Standardized biological methodology – are there standard protocols to measure impact on biology in an area?
- Metal speciation/bioavailability

GROUP: YELLOW
PROJECT TITLE: Refinement of risk assessments **DETAILS:** Refinement would include pathways from mine wastes to the environment and linked to human health.
PROJECT TITLE: Relate environmental monitoring in streams back to water quality **No details:**
PROJECT TITLE: Monitoring tools for the environment (remote sensing) **DETAILS:** Research would be done at sites that include: ▪ Triggers ▪ Continuous data feed ▪ Remote sensing
PROJECT TITLE: Guidelines for life of mine **DETAILS:** Include best practices for all stages of mine life
PROJECT TITLE: Geoenvironmental ore deposit model **DETAILS:** Issues included would be: ▪ Mine life cycle (exploration – metallurgy – environmental) ▪ Interactive model to determine effects from all inputs (geology, process, mitigation) ▪ Potential problems that could arise and possible technologies to use
PROJECT TITLE: Manual or document for integration of disciplines **DETAILS:** Project management – integration of geology, metallurgy, engineering, environmental issues
PROJECT TITLE: REVIEW OF SELECTED SITES FOR THE PREDICTED PERFORMANCE **DETAILS:** Includes costs of the full mine life cycle **The following projects were grouped under this Project Title:** **PROJECT TITLE: Data on rehabilitated sites to verify status** **DETAILS:** Research would include: ▪ Does the rehabilitation scheme work (dry covers, wet covers, etc.)? ▪ How do the end results relate to the predicted concepts of how the site would evolve over time? ▪ Through this work, derive a reliable model for prediction at other sites **PROJECT TITLE: Evaluation of models over the long term** **DETAILS:** Issues included in this work are: ▪ Relate real life situations to validate assumptions ▪ Assess the reliability of models **PROJECT TITLE: Case studies of ore bodies** **DETAILS:** Research would look at the whole life cycle with cost implications. Did the property make money when all factors were considered from exploration to closure?
PROJECT TITLE: Re-assessment of prediction tools **DETAILS:** Focus on tools for the early screening of acid potential of properties **The following projects were grouped under this Project Title:** **PROJECT TITLE: Early screening tools to assess the ARD potential of properties** **DETAILS:** Research include work in the area of: ▪ Geochemical basis – possibly sulphur species ▪ To be used for quick determinations of acid potential during due diligence phase **PROJECT TITLE: Re-assessment of existing prediction tools** **DETAILS:** How well have the existing tools predicted the actual field conditions at sites?

GROUP: ORANGE

PROJECT TITLE: Detailed post mortem on closed mine sites that have historic analytical testing modelling

DETAILS:

- Could be short-term post-closure and long-term post-closure too.
- A lot of work had been done, test methods, models etc. but need to go back and study
- DB was considering a similar approach but hers were on surface water
  - i.e. a follow up on prediction monitoring on water sources in the field.
- This would be a reality check on how the prediction models work
- Now that we have modelled it, does it work like it was designed? to.
  - this is rarely done – and if it is it is done only as an internal project
  - need a database that makes the info available
- A field validation for the long term – offers a change to refine the models
- But one needs to define the goals – is it monitoring or research and model development?
  - answer – It's research, the research does not stop with the model – it needs a reality check
- There should be a focus on current best practices (or in the case of older sites, what was thought to be best practice. Can assess historic sites in the context of what was best practice, what is current best practice and what the system's current behaviour is.
  - eg. find a water cover that is 10 years old for study
  - (this may not be the best example, some MEND studies have done this)
  - if specific shortcomings can be identified then they can be documented and gaps identified for further assessment
  - in this context, negative verification can be valuable
  - also why things went wrong and how to fix
- The model development should also consider the "non-base" metals

PROJECT TITLE: Biogeochemistry dynamics of AMD/ARD effluents in relation to feedback of analysis modelling and prediction

DETAILS:

- When dynamics is related to water covers then thiosalts and other flotation byproducts may need to be considered for mines in operation
- Possible relation to "detailed post mortem on closed mine sites that have historic analytical testing modelling"

PROJECT TITLE: Prediction models for non base metals

No details.

PROJECT TITLE: Identify And Characterize Limitations Inherent In Current Modelling Methodologies And Technologies To Make Explicit How These Methodological And Technological Characteristics Impact Risk Assessment

DETAILS:

- Level of certainty should be explicit
- Can we trust the RA, what are the limitations (needs to be expressed up front)?

The following project was grouped under this Project Title:

PROJECT TITLE: The assessment of technologies or management options to understand the cost benefits to determine the full and true benefit of the treatment option

DETAILS:

- Also want to include what is needed to avoid ongoing treatment as the final management options.
- Eg. Covers are an answer but you generally find you have to treat anyways – there may be better options.
- What is the relative cost benefits

GROUP: ORANGE, Continued

PROJECT TITLE: Fundamental research to get data to characterize tailings
DETAILS:
- Would include basic mineralogy on secondary minerals.
- It would improve modelling predictions and overcome model limitations.
- Would include "minor" elements such as arsenic.

(Note: There are ongoing projects by individuals in these areas that require periodic updates of the research summaries that are not always easy to find because they are published in specialized journals/proceedings that are not always focussed for a mining audience.)

PROJECT TITLE: Ecosystem modelling, what are the acceptable effects from mines?
DETAILS:
- Use EEM data now within the regulatory system to evaluate the environmental effects related to a specific ARD prevention method.
- A more philosophical type of issue.
- What does a non-zero effect really mean
- Most agreed that mining will have effects
- What are the long terms effects
- We are really talking about values for Canadians
- Need to define the risk assessment for mines (not necessarily based on protection of 100% of the species 100% of the time.

GROUP: RED

PROJECT TITLE: Geochemical Prediction of Pit Water
DETAILS:
- 3 climatic conditions
- Soluble salts
- Predictions and follow-up via monitoring (audit)
- Audit (verification of assumptions)

PROJECT TITLE: POST-AUDIT MODELLING
DETAILS:
- Verification of Past Modelling with true "observed" data
- Some models such as RATAT developed 8-10 years ago. Should examine past predictions based on data
- Evaluate and disseminate positive/negative results
    - i.e. MineWall not very good
- Observation that model is as strong as person driving it, need experience to suitably apply
- Model is the genesis – to be refined. Company is able to refine model to make applicable to site.
- To refine – need to collect information, find the reasons for failure
- For audit – Need "observed" data

The following project was grouped under this Project Title:

PROJECT TITLE: Modelling Development/Application
DETAILS:
- MEND toolkit needs to be re-evaluated and updated
- Lots of good tools out there: should look at their application
- Samatoscan – no follow-up; MEND study one time shot application
- Move audit into application
- Project can be completed in 1 year
- Predictive model: Comprehensive survey to look for the differences - Data is out there
- More data has been compiled ; long term and short term
- Closed mine sites habited by fish ; biological activity affects prediction
- Predictive model does not incorporate all tools (metal adsorption)

GROUP: RED, Continued

PROJECT TITLE: Refinement of Co-Characterization and Prediction

The following projects were grouped under this Project Title:

PROJECT TITLE: Standard tests
DETAILS:
Standard protocols needed for kinetic tests (i.e. humidity cells). Common ground
People will choose what suits their needs – unless test is a regulatory requirement
Note: MEND mandate does not include regulatory tests.

PROJECT TITLE: Methods to transfer laboratory data to field data
DETAILS:
Question of QA/QC – can not compare what industry and consultants are doing.
Suite of options right now. Can be misleading i.e. arsenic test after 2 weeks and 2 years.
Need to understand what occurs in laboratory conditions compared to field to scale-up

PROJECT TITLE: Reduce "grey zone" in prediction for low-sulphide material
DETAILS:
Develop better methods or studies relating to low-sulphide waste rock.
Billions of tonnes of low-sulphide waste rock fall under "grey zone". Influence waste handling practices.
Affects diamond industry. Financial liability.

PROJECT TITLE: Metal Loadings From Waste Rock
DETAILS: Geochemical evaluations linked to hydrology; comparative, varying climate site

The following projects were grouped under this Project Title:

PROJECT TITLE: Link hydrology and geochemistry to predict metal leaching of waste rock
DETAILS:
Increase understanding of waste rock piles
Coarse waste rock
Mt. Washington site discussed as example
Survey to study geochemistry (metal loading) and hydrology (how metal gets into environment)

PROJECT TITLE: Modelling for Waste Rock
DETAILS:
Hydrology in waste rock

- Hydrology in permafrost. Infiltration as precipitate flows through pile.
- Variable temperature environment
- Testing method to determine hydrological behaviour in laboratory; Micheal Li did work in this area with a huge column. Very site specific issue. Expensive study
- Definition of waste rock is quite wide

PROJECT TITLE: Thermal modelling of waste rock pits in the North
DETAILS:

- Approved method of analysis of temperature in waste rock pile
- Permafrost used extensively in North i.e. engineering of frozen core structures;
- What effect climate change have on practice/technology

GROUP: RED, Continued

PROJECT TITLE: INDICATORS OF EARLY SULPHIDE OXIDATION

The following projects were grouped under this Project Title:

PROJECT TITLE: Onset of metal leaching
DETAILS:
Methods to understand the mechanisms that occur prior to metal leaching
Pre-metal leaching
What 's happening before metal leaching
i..e. Polycyanates as early indicators
Indicators of early onset of sulphide oxidation for kinetic test work

PROJECT TITLE: Method for surface characterization
DETAILS:
- Mineralogical
- Chemical
- Physical
- Benefit: early onset in field.
- Onset of Metal Leaching
- Early onset indicators – sulphide oxidation
- Early period prior to metal releases
- ABA tests – focus on acid generation
- Other reactions occurring
- Glavanic interactions
- Sulphide oxidation
- Polycyanates are early indicators of sulphide oxidation
- Presently, no focus on early period
- Impact ions have is bid
- EDTA extraction to detect early build-up on surface
- Metal adsorption process – metal ihydroxyl on surface; lock in place
- Eventually surface saturated; metal release occurs

Link laboratory work on onset to the field

PROJECT TITLE: Metal Leaching at Low Temperatures
DETAILS:
- Prediction in low temperature conditions
- Prediction of metal leaching in low temperature environments

PROJECT TITLE: Prediction of far field transport
DETAILS:
- Not considered by MEND
- Beyond tailings and waste rock

GROUP: GREEN
PROJECT TITLE: Research dry covers: from design to natural system **DETAILS:**
PROJECT TITLE: Research Implication of climate change **DETAILS:** North Watch is looking at mines in the Lake Superior basin – water covers are being used, but climate change issues are not being considered ▪ What level of detail is required to satisfy the needs of stakeholders? Is the current level sufficient?
PROJECT TITLE: Verification/Audit of existing technology **DETAILS:** Work related to monitoring facilities has been done – current technology should be reviewed)
PROJECT TITLE: Define Long-term Performance **DETAILS:** Perhaps a different terminology should be used
PROJECT TITLE: Oxidation kinetics at low temperatures **DETAILS:** With more arctic mines being developed, combating acidic drainage and metal leaching needs to be researched in the context of cold temperatures (e.g. below 2°C) ▪ Design of closure: research information (what has been done in laboratories? Case histories?); in the arctic there seems to be a lack of information regarding oxidization at lower temperatures (information up to 2 degrees, but not lower – yet kinetics change dramatically in the 0 – 2 degree range). ▪ Design of waste pile: in arctic, can it be permanently frozen if the oxidization produces heat (and hence melts the permafrost)? Basic research needs to be conducted before a model is developed – to understand the process that is being modeled. A research project would be done in increments (approximately one year in length) ▪ Note: there is a standard model for heat transfer and heat loss – but maybe not appropriate or specific enough.

APPENDIX E: DETAILED PROJECT DESCRIPTIONS -THEME 2

GROUP: BLUE
PROJECT TITLE: Mine Waste Management, planning, financial, environmental effects **DETAILS:** **Outcome:** Development of a new financial model (one possible) **Relevance:** Financial planning for all stages of mining **Short/Long-term deliverables:** Evaluation of existing approach and development of new/alternative approaches **Funding/Partnership Opportunities:** Linkage to other groups on abandoned and orphaned mines Research under this topic includes: ▪ Framework for evaluating waste management alternatives ▪ Assess environmental impact from abandoned sites with respect to changes over time, extent of impact, biological considerations ▪ Evaluation of Net Present Value (NPV) model for costing of mine waste management ▪ Cost-benefit analysis of progressive closure ▪ Criteria for integrated engineered mine closure plans ▪ Sustainable development – future use of sterilized areas such as covers ▪ Are we making the most effective use of existing data sets (e.g. for long-term effects)? ▪ Develop solid cement for consolidating tailings
PROJECT TITLE: Permafrost **DETAILS:** **Outcome**: Maximize utilization **Relevance:** Support for mine developments in the north **Short/Long-term deliverables:** Evaluation of existing permafrost models/new methods for managing wastes in the north **Practicality, clarity, focus:** No shortage of cold temperature conditions Research under this topic includes: ▪ Enhanced use of permafrost
PROJECT TITLE: Novel Covers **DETAILS:** Alternative Cover Materials (co-mix – tailings, waste rock, slag)
PROJECT TITLE: Performance of Wet Covers **DETAILS:** Research under this topic includes: ▪ Wet covers – long-term monitoring of flooded tailings to understand geochemical processes, re-suspension aspects ▪ Investigate the long-term performance of water covers, especially on oxidized tailings
PROJECT TITLE: Biological Treatment (passive) systems **DETAILS:** Research under this topic includes: ▪ Evolution of constructed wetlands (treating mine drainage in natural wetlands) ▪ Develop options for long term treatment (e.g. bioremediation) ▪ Microbial ecology and ARD associated with broad reuse and disposal of waste rock
PROJECT TITLE: Alternative use of other industrial waste **DETAILS:** Using industrial wastes from other business sectors for prevention and control of mine drainage.

GROUP: YELLOW
PROJECT TITLE: Predictive testing for non acid contaminant leaching **DETAILS:**
PROJECT TITLE: Risks associated with passive treatment systems **DETAILS:** Research would include issues related to long-term risk of putting metals into a wetlands system – biological uptake and possible chemical remobilization
PROJECT TITLE: Reduce volume of reactive waste or reactive portion of waste by removing other products that can be sold **DETAILS:**
PROJECT TITLE: LONG TERM USE OF SITES AND ASSOCIATED LAND USE AFTER CLOSURE **The following projects were grouped under this Project Title:** **PROJECT TITLE: Long term use of sites after closure and remediation** **DETAILS:** Research would cover: ▪ What can they really be used for in the long term? ▪ Any land use restrictions associated with remediated site **PROJECT TITLE: Compare metal uptake by vegetation and wildlife in tailings areas** **DETAILS:** Evaluate metal uptake at various closed or long-term operational sites
PROJECT TITLE: Geochemical stability of paste backfill for underground operations (long-term) **DETAILS:** Work would include consideration of: ▪ How stable is paste backfill in underground? ▪ Will metals be released in the future?
PROJECT TITLE: Fundamental research on microbiology **DETAILS:** Sludge, creekbeds, microtox testing
PROJECT TITLE: Climate change **DETAILS:** Compare ore bodies of similar type but different climates to determine impact of climate on oxidation reaction rates (North vs South)
PROJECT TITLE: Design site for erode-ability with ultimate closure in mind **DETAILS:** Ultimately all products will be eroded so incorporate into design so that when the products are eroded there is limited impact on the environment

GROUP: ORANGE
PROJECT TITLE: Develop Integrated Options to Manage and Prevent ARD **DETAILS:** There are options that don't work in all cases: ▪ Vegetation on water covers is not appropriate for U tailing deposits (OK for base metals) ▪ As well, the wet covers and thiosalts (during operations – not considered an issue after mill closure)
PROJECT TITLE: Define BMP through a critical review of current practices in Canada and other jurisdictions No details.
PROJECT TITLE: What happens to the wetland itself? **DETAILS:** Provides a mechanism to integrate the biological response to the management decision or managing process
PROJECT TITLE: Integrate biological effects into management decisions No details.

GROUP: ORANGE, Continued

PROJECT TITLE: Develop practices related to phytoremediation and harvesting
DETAILS:
- Would be a way to rework old tailings – extractive
- Reprocess the metals by harvesting the plants
- Could be cost effective

PROJECT TITLE: Modelling and monitoring of accepted practices (Case Studies)
DETAILS:
- Linked to theme one part on modelling
- Would build on case studies on and how the modelling works
    - e.g. Use waste rock in place for 5-10 years
        - or flooded pits
- We have developed models but they have not been validated with monitoring data since.
- Water quality would be one focus of studies
- Could apply to underground disposal and ground water

PROJECT TITLE: Non – AMD tailings and solid liquid separation before depositing
DETAILS:
- Develop processes for separating solid and liquid portions of tailings before disposal
- An alternative to tailings ponds
- May make water management easier
- Creates a smaller footprint
- Objective would be to pile dry waste
- Has to be non acid generating
- Material may have commercial value

PROJECT TITLE: A review of productive uses of sites and waste material
DETAILS:
- Finding values in waste
- Heat recovery, fish farms, dam building, bat caves, etc.

PROJECT TITLE: Economic Analysis of Selective Mining Activity
DETAILS:
- A full cost accounting of mining and consider the realistic closure costs and the economics of marginal deposits

PROJECT TITLE: Disposal of sludge underground (or under water) and its impacts
No details.

PROJECT TITLE: Looking at the advantages of progressive closure (case studies) to illustrate the economics
No details.

PROJECT TITLE: The chemistry of discharge from previously oxidized tailings deposited in pit or underwater as a reclamation alternative
DETAILS:
- The effect on the water column or on groundwater discharge has not been adequately assessed
- This would start with a discussion of what criteria need to be evaluated

GROUP: RED

PROJECT TITLE: Fundamental research on liquefaction and seismicity

DETAILS:
- Geotechnical standard
- Waste management

GROUP: RED, Continued

PROJECT TITLE: Innovative waste handling technologies
DETAILS:
- Desulphurisation, paste backfill, metal recovery

The following projects were grouped under this Project Title:

PROJECT TITLE: Natural attenuation technologies for metal retention
DETAILS: Soils

PROJECT TITLE: Innovation waste handling
DETAILS: Prevention of AD, desulphurisation, paste backfill

PROJECT TITLE: Metal recovery from waste
DETAILS:
- Recovery of metal values from sludge/tailings
- Treatment of tailings
- Metals recycled $$

PROJECT TITLE: Biological support and secondary barriers in water cover technologies
DETAILS: Offsite impacts

The following projects were grouped under this Project Title:

PROJECT TITLE: Biological uptake in water covers
DETAILS:
- Biological support for water covers (Noranda/Louvicourt)
- Monitoring

PROJECT TITLE: Secondary barrier for water covers
DETAILS: e.g. Algae/sand on top of tailings

PROJECT TITLE: Standardized method for dry cover performance (oxygen transfer)
No details.

The following project was grouped under this Project Title:

PROJECT TITLE: Long-term performance of dry covers
DETAILS: Dry covers – effect of vegetation on integrity/performance of cover

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PROJECT TITLE: Passive Treatment
DETAILS:
- Island Copper
- Flow is an issue
- USA has done a lot of work in this area
- Research needs to be conducted in relation to Canadian climates
- Winter performance
- Natural attenuation for metal recovery
- Behaviour when pH<3.5

PROJECT TITLE: Construction of dry cover/wetland combination
DETAILS:
- Strategy to reduce metal loadings.
- Landscape redesigned to reduce export of contaminants.
- Mine Waste management practices.

LB note: Covers not the best option; problem always there

GROUP: RED, Continued
PROJECT TITLE: Construction of dry cover/wetland combination **DETAILS:** ▪ Strategy to reduce metal loadings. ▪ Landscape redesigned to reduce export of contaminants. ▪ Mine Waste management practices. ▪ LB note: Covers not the best option; problem always there
PROJECT TITLE: Mine waste management in low temperatures **The following project was grouped under this Project Title:** **PROJECT TITLE: Long-term performance of frozen core dams** **DETAILS:** ▪ Includes analysis of performance of frozen waste rock piles and tailings, paste backfill ▪ Permafrost with respect to containment structures ▪ Reactivity of waste under cold climate
PROJECT TITLE: Ecological impacts of water covers **DETAILS:** biological component of metal uptake; wildlife – aquatic effects and risk
PROJECT TITLE: Reduction of biological interference in waste management scenarios **DETAILS:** ▪ Biological impact caused by beavers ▪ Preventive maintenance and post-closure management ▪ Syncrude – beavers are past of reclamation plans
PROJECT TITLE: Sludge densification **DETAILS:** ▪ Can we make sludge even denser i.e. 40 –50-60% ▪ May not be cost effective – would need large number of reactors ▪ Metal recovery from AMD? ▪ Another option to add cement to sludge – prevent leaching, store safely

GROUP: GREEN
PROJECT TITLE: Dissemination of Information **DETAILS:** ▪ Companies have indicated that they will share information, rather than keep it as part of company information resources. ▪ MEND should disseminate information arising from relevant activities; communication is an important element of all themes ▪ There is goodwill among stakeholders to release reviews to avoid duplication and increase complementary research projects. ▪ Many companies are too small to be in INAP, and hence their ability to track current research is limited. The current means of communication is through personal networking – this could be greatly improved with additional communication and provision of information through the MEND network
PROJECT TITLE: Pre-treatment of tailings before discharge: **DETAILS:** Tailings are being pretreated to remove elements such as arsenic in Saskatchewan.

GROUP: GREEN, Continued
PROJECT TITLE: Re-visit passive treatment **DETAILS:** ▪ Wetlands or other biological and chemical means of mitigation. There are conditions where these treatments are working – perhaps focus should be on identifying suitable conditions for passive treatments, rather than trying to make them work for all or any conditions. Research in this area would be helpful – what are design parameters and conditions? ▪ There are applications for passive treatment in terms of secondary treatment, not necessarily primary treatment. ▪ A passive system is working quite well in Québec – limestone and peat filters. ▪ Passive system: It should be seen as part of the solution, not the only solution. It should be integrated with other mechanisms and mitigation measures. We should be aware that we are susceptible to "fashion" – convinced to do certain activities based on what is visible at the time. Innovation exists, technology exists, the key is to have the industry use these solutions instead of continuing to make use of existing measures.
PROJECT TITLE: Performance of in-pit disposal systems **DETAILS:** Open pit disposal: technology is not universal, but additional research would be helpful. The volume of tailings is relatively small – but the importance of this suggests that it should still be dealt with. Nonetheless, there is very little data available. Research programs need to initiated to determine the impacts of open pit disposal.
PROJECT TITLE: Protocols for performance modelling **DETAILS:** Would it be useful to develop protocols on how to collect data, and what data should be collected to support decision-making? Should this perhaps be done outside of MEND?
PROJECT TITLE: Sludge Re-use Options **DETAILS:** Can sludge be recycled or reused? This could be researched with respect to chemical stability, etc.

APPENDIX F: DETAILED PROJECT DESCRIPTIONS - THEME 3

GROUP: BLUE
PROJECT TITLE: Projecting soil development, soil/sub soil hydrology and plant succession **DETAILS:** Research would focus on long-term effects
PROJECT TITLE: Linking Scientific Developments to policy changes No details.
PROJECT TITLE: Progressive reclamation versus holding out for emerging technology **DETAILS:** What is needed is a summary of where this is being done, and what is being done. There are trade-offs in dealing with an environmental issue using present technology, and it may be better for all concerned to wait for some better technology to be developed in the future.
PROJECT TITLE: Effects of re-opening mines **DETAILS:** Research would involve determining the effects of reopening mines, the environmental effects and the regulatory framework that is in place to manage the process. Details: regulatory framework, environmental effects evaluation, value benefits recycling, risks Outcome: Discussion Paper
PROJECT TITLE: Cumulative effects (in pristine areas) **DETAILS:** Each industry should be able to identify its effect on the environment; issues that could fall in here would be metal availability, metal speciation, As/Se speciation (these are not presently being handled by anyone). There was some discussion about how background levels are treated and what should be achieved – some policy development is necessary. In many cases we don't know what the background is, or how to measure it. It was felt that some of this is being dealt with in the Guidance Document for EEM. Details: protocols for assessing assimilative capacity, baseline methods, regulatory/policy review; definition of benign/background **Outcome:** Manual **The following projects were grouped under this Project Title:** **PROJECT TITLE: Definition of environmentally benign for "walk-away"** **DETAILS:** Is there such a thing as inert mine waste? This project is linked to the following: ▪ Need to establish background levels/ranges for trace metals in pristine settings; this may be a question that is best dealt with by policy makers. There is a need to determine the background or baseline for a specific environment, and how close to this is it necessary to come before the mine is designated as closed. **PROJECT TITLE: Cumulative impacts of new mines in pristine watersheds (i.e. before any industrial development)** No details.

GROUP: BLUE, Continued

PROJECT TITLE: Community support
DETAILS: It was felt that the natural evolution of MEND is to be a clearinghouse beyond industry; this primarily involves providing materials that can be used by the public. Communications should be a two way; it therefore involves a fair amount of capacity building in the public which would create a level playing field when technical/scientific issues are being discussed by mining companies. This may apply more to remote areas and developing countries. At the same time industry could learn from the public. It was felt that this should be done by MEND and not MAC because MEND is seen as a more neutral party.
Details: community support means all stakeholders; this involves capacity building (training, etc.) it is global; the main focus is communications
Outcome: Broadening the understanding of issues by all stakeholders

The following projects were grouped under this Project Title:

PROJECT TITLE: Public Engagement
DETAILS: Managing expectations and communicating back to the public about what the imparts are of mining

PROJECT TITLE: Community capacity building as an Emerging Challenge
DETAILS: If mines expect to build a relationship with the public, then they have to try to build capacity within the community

PROJECT TITLE: Productive use of wastes
DETAILS: There was some discussion about recycling of wastes. There are benefits in reducing the volume of wastes which could be done by finding alternative uses. For example: pulp and paper waste is being used as an organic cover for some mine tailings.
Details: definition and use/impacts of "benign" wastes, stabilization of reactive wastes and use, stabilization of metallurgical and reacted wastes;
Outcome: identification of new revenue streams;

The following projects were grouped under this Project Title:

PROJECT TITLE: Definition of environmentally benign for "walk-away"
DETAILS: Is there such a thing as inert mine waste?
This project is linked to the following:
- Need to establish background levels/ranges for trace metals in pristine settings; this may be a question that is best dealt with by policy makers. There is a need to determine the background or baseline for a specific environment, and how close to this is it necessary to come before the mine is designated as closed.

PROJECT TITLE: Beneficial utilization of mining waste for use as building or construction materials
DETAILS: This includes discussion of the potential use of reagents for other processes

PROJECT TITLE: Extend MEND to Metallurgical Wastes
DETAILS: metallurgical wastes include slag, jarosite, etc.

PROJECT TITLE: Alternative Cover Materials
DETAILS: It is a challenge to find cover materials for engineered covers, especially in remote areas

PROJECT TITLE: Effects of Climate Change
DETAILS: It was decided by the group that this item cuts across many of the themes and was put in the parking lot to be discussed further if time warrants.

GROUP: BLUE, Continued

PROJECT TITLE: Managing permafrost effects in containment facilities
DETAILS: Permafrost areas are not actually stable areas they are fairly active chemically and biologically, the challenge is getting permafrost to form where you want it and not forming where it is not beneficial. Details: design of facilities to avoid possible effects such as frost heave, etc.; outcome: evaluation of effects, **Outcome**: Design guides.

The following projects were grouped under this Project Title:

PROJECT TITLE: Tailings in continuous/discontinuous permafrost
DETAILS: Pingoes, ice lensing, biological activity

PROJECT TITLE: Permafrost
DETAILS: Stability of permafrost, frozen core technology

GROUP: YELLOW

PROJECT TITLE: Mobility of As, Se, Sb, Mo, Ni, Tl, Te (oxy-anions)
DETAILS: Research would include:

- Trace elements associated with several types of ore bodies and can become soluble in various environments
- Require prediction and remediation planning
- Phase One **-** complete literature review on metals of concern – start with As & Sb
- Phase Two **-** laboratory based work to investigate solubility controls, mineralogy of secondary precipitates, role of micro-organisms, and adsorption behaviour
- Ultimately use for design of remediation and prediction models

PROJECT TITLE: Review techniques for tailings passivation
DETAILS: Research would include:

- Useful for management of sites
- Use existing technologies to minimize long term impacts (ex. Desulphurization, pressure oxidation, Dupont – permanganate)
- Removal of sulphur from tailings for use in covers or exposed beaches – if cost efficient then may be able to remove for entire tailings volume
- Complete a report on cost benefit analysis on case studies of existing properties using different processes and technologies to passivate tailings
- Review long term stability
- Investigate applicability for operating and closed sites
- Will reduce long term liability

PROJECT TITLE: Chemical stability of encapsulation technologies
DETAILS: Research would include consideration of the following:

- Ensure that assumption that we are dealing with materials for perpetuity is correct and not creating future problems
- Include a pathways analysis and look at climate change factors
- Phase 1 would be to start with evaluation of paste backfill since technology is used extensively so there are several sites to research
- Phase 2 would look at other technologies such as bauxol
- Identify technologies that may work for encapsulating waste rock

GROUP: YELLOW, Continued
PROJECT TITLE: Evaluation of ARD in exploration phases **DETAILS:** Research would include consideration of the following: ▪ Produce a manual or guide for minimizing and evaluating ARD potential at early stages of mineral exploration ▪ Short term – manual to identify impacts ▪ Long term – avoidance of impacts through proper management at early stages of exploration ▪ Overall benefit to reduce impacts and dollars spent on rehabilitation of sites ▪ Often the exploration geologist has the first contact with the community so should be aware of issues ▪ Exploration provides a good opportunity to collect information at the early phases to guide mine development
PROJECT TITLE: Surface chemistry of sulphide minerals **DETAILS:** Research would include: ▪ Fundamental research on oxidation and metal release mechanisms from sulphide minerals ▪ Stage 1 – review existing data on common sulphide minerals to consider implications to ARD metal leaching (prediction/mitigation) – work exists on pyrite, pyrrhotite, marcasite, loellingite, arsenopyrite ▪ Stage 2 – fill in gaps for minerals not covered in Stage 1 for surface oxidation – need to evaluate stibnite, chalcopyrite, and sphalerite

GROUP: ORANGE
PROJECT TITLE: Review trends on sub-aqueous disposal from sustainable development criteria **DETAILS:** ▪ Develop understanding of short term impacts and the recovery period and response in the long-term
PROJECT TITLE: Degradation and environmental outcome of the process metallurgy on the ecology **DETAILS:** Cyanide, flotation reagents, thiosalts and etc.
PROJECT TITLE: Sustainable Development, raising sights **DETAILS:** ▪ Post-closure benefits from mine operations ▪ Social, economic, ecological ▪ Focus currently is now on ecological in terms of regulation   o ie. vs the limited approach of minimizing adverse effects ▪ Probably a cross cutting theme
PROJECT TITLE: ARD mitigation in difficult environments **DETAILS:** ▪ Compilation of studies ▪ E.g. Heavy snow loads, etc.
PROJECT TITLE: Groundwater Issues **DETAILS:** Consider groundwater as a resource and consider how this may affect current impact assessments and licensing/permitting

GROUP: ORANGE, Continued

PROJECT TITLE: Creating benefits (or beneficial values) from waste and mine facilities at end-of-life
DETAILS:

- Do a review and try to develop alternatives for waste management with a view to creating benefits or finding value for both wastes as well as mine facilities at end of life
- This could include matching or mixing with wastes from other industries
- Includes the 3Rs
- One example is to concentrate sulphides to reclaim (or produce) the non-sulphide fractions
  - Idea is to get the value our of the non sulphide
  - Might be useful as a cover material

The following projects were grouped under this Project Title:

PROJECT TITLE: Extract a clean (non-sulphide) waste from tailings to use as a resource such as over material were alternative materials are scarce (e.g. Arctic)
No details.

PROJECT TITLE: Co-disposal synergies of wastes from other industries
DETAILS:

- Landfill and tailings pulp and paper, etc.
- Landfill, metal, steel industries, landfilling, biosolids

PROJECT TITLE: Post-operational alternatives to closure uses
DETAILS: Consider alternate or non-traditional uses

- Are there uses that would provide new or added value?

PROJECT TITLE: Other uses (beneficial) for wastes
DETAILS: Does not include consideration of waste tailings

GROUP: ORANGE, Continued

PROJECT TITLE: Engineering natural analogues to mitigate impacts and retain contaminants
DETAILS:
- Need to do a review of study sites that exist already
- The idea is to investigate:
  - Bioavailability
  - Metal bioavailability
  - Errosion
  - Sediment effects
  - Weathering and corrosion

The following projects were grouped under this Project Title:

PROJECT TITLE: Bioavailability of metals in environmental media
DETAILS:
- Humic substances (natural organic matter)
- Flotation reagents
- Particulate vs. dissolved

PROJECT TITLE: Study As mobility in wide pH range
DETAILS: This is an area of intense and voluminous research
- A critical summary that updates current understanding in the mining context might be useful

PROJECT TITLE: Ecological engineering in the light of MEND objectives
DETAILS: Natural processes and third party evaluations

PROJECT TITLE: Ecological engineering projects to identify future needs
DETAILS: Groundwater contamination, natural mimicry

PROJECT TITLE: Erosion/sediment control in the long-term
DETAILS: How can you use natural environmental processes to get things back to natural conditions (i.e. less dependence on engineered solutions)?

PROJECT TITLE: Develop and/or Review standard procedures and protocols for estimating reclamation costs
DETAILS: Make information available to the public

GROUP: RED

PROJECT TITLE: TDS Treatment

DETAILS:

- Sulphate ; Regulated in states – not in Canada
  No economic process i.e. reverse osmosis $$
  Important for water management/recycle
- Major Ions – Ca2+, Mg +, Cl- (egological effects; major problematic ion of diamond mines; open pit at depth will genearally have high Cl- as it is part of groundwater regime)
- Emerging regulations in Canada for toxicological effects (link with government for aquatic effects (EEM)

The following projects were grouped under this Project Title:

PROJECT TITLE: Thiosalts
DETAILS: CANMET has thiosalt consortium – but results internal

PROJECT TITLE: Sb, Cd, As, Se, Hg – Hard to treat elements
DETAILS: Development of cost-effective treatment methods

PROJECT TITLE: Thiocyanate
DETAILS:
Issue for Equity

- Should integrate with MEND and other programs
- Other issues ammonia, cyanide, lasting residues
- Progressive closure and reclamation
- Reports to characterization and water

PROJECT TITLE: Co-disposal pilot tests
DETAILS:

- Operational aspects
- Pilot testing for co-disposal methods
- Tailings and waste rock do not exist naturally together
- Heterogenous mixture – complex behaviour

PROJECT TITLE: Effects of climate change on AD management strategies and reclamation solutions
DETAILS: Discussion on climate change. How real is it / how measurable. Some models inaccurate (RATAP still good). Experts are formulating climate change models.
Too early in game to include. AD strategies and designs should be robust enough to adapt to climatic changes

PROJECT TITLE: Novel milling process to reduce environmental impact of mine waste
DETAILS:

- e.g. Tailings for use as soil
- Novel treatment
- In process: use of flocculants
- Post treatment of tailings (i.e. Add paper sludge)
- Amend tailings to produce a suitable product
- Tailings by themselves cannot be used as “soil”

GROUP: RED, Continued
PROJECT TITLE: Assess cumulative impacts in large watersheds **DETAILS:** ▪ Government set up framework for cumulative effects ▪ What to do if scale-up does not work ▪ Programs look a snapshot – need to look at continuous effects over long period ▪ Interface with government to ensure that guidelines are looked at. ▪ Part of aquatic effects; tied in with toxicity in effluents; MITE TIME ▪ Partnership opportunities **The following project was grouped under this Project Title:** **PROJECT TITLE: Determination of cumulative ecological impacts of effluents near field (end of pipe)** **DETAILS:** ▪ Far field (watershed) ▪ Assessing cumulative impacts in large watersheds ▪ How develop limits for discharge
PROJECT TITLE: Integration of water cover and wetlands No details.
PROJECT TITLE: Waste deposition in existing water bodes (lakes, oceans) **DETAILS:** ▪ Site specific application ▪ Possibility when surface impoundment is not an option (topography, etc.)
PROJECT TITLE: Impacts/Benefits of Mining as a standardized methodology **DETAILS:** ▪ Socio-economic considerations ▪ New ways to measure impacts of mining ▪ Fraser Institute work can be built upon ▪ Everyone appears to have a bias in these assessments **The following projects were grouped under this Project Title:** **PROJECT TITLE: Assess cumulative impacts in large watersheds** **DETAILS:** ▪ Government set up framework for cumulative effects ▪ What to do if scale-up does not work ▪ Programs look at snapshot – need to look at continuous effects over long period ▪ Interface with government to ensure that guidelines are looked at ▪ Part of aquatic effects; tied in with toxicity in effluents (MITE TIME) ▪ Partnership opportunities **PROJECT TITLE: Communication of known conditions versus unexpected conditions** **DETAILS:** ▪ Avoid unpleasant surprise (ammonia, chloride) ▪ Communication of uncertainty

GROUP: GREEN

PROJECT TITLE: Guidelines for long-term designs
DETAILS:
- Progressive reclamation
- Revegetation
- Erosion control
- Slope stability
- These are tools for the designers and operators. Provide guidelines for geochemical work for segregation of rock. Could be based on case histories and guidelines. (Restigouche in NB was mentioned here as an example). Guidelines should be developed and the best place may be the auspices of MEND. The regulators will have the ultimate decision at the end
- Program could benefit by referring to the uranium industry. There are many national and international guidelines on uranium mines tailings management, particularly on long-term issues.

PROJECT TITLE: Design concepts/case histories of blending/selective placement
DETAILS:
- Design concept for blending and placement of material. Selective placement goes together with progressive reclamation.

PROJECT TITLE: Methodology for segregation of rock
DETAILS:
- Selective placement in dumps
- Methodology for the segregation of waste rock. This would be beneficial for waste rock dump construction where the sulphide waste could be encapsulated by the non-acid generating materials. Need methods to be used by field personnel (e.g. geologist, engineer) for easy identification. Could use drill cuttings from blast holes to analyze waste for proper identification.

PROJECT TITLE: Develop guidelines and management principles for the life-cycle
DETAILS:
- Mining waste guidelines/principles
- Guiding principles - long-term issues, what is the long-term?

PROJECT TITLE: Closing underground workings – effect on groundwater
DETAILS: Emerging groundwater from underground workings – monitoring the contamination from the seepage and prediction of effects. The challenge is bringing the older mines to standards. Groundwater is an emerging issue that will need further investigation

PROJECT TITLE: Co-disposal
DETAILS:
- Co-disposal of waste rock/tailings in pits and underground mines.
- Practical methodologies for co-disposal
- Cost effective, full-scale application
- Advantages of tailings; advantages of waste rock.
- Investigation into factors affecting co-disposal of waste rock and tailings.
- Project to look at feasible full-scale methodologies for co-disposal.
- Co-disposal – INAP has completed a review of the literature and have completed some field trials at Placer's Porgera mine site. The laboratory work focussed on the concept that it could be done – small scale. Mixing is done at the lab scale and shown to work. The next step could be to make it work in the field.

PROJECT TITLE: Developing the knowledge about: hydrogeotechnical behaviour of waste rock piles and developing the according models
DETAILS:
- Hydraulic aspects of waste rock (moisture retention/permeability) in relation to circum-neutral drainage .
- Project could be using non-INAP companies that are moving waste rock into a pit.

GROUP: GREEN, Continued
PROJECT TITLE: Multi-parameter investigation into neutral pH metal leaching **DETAILS:** ▪ Both chemical and physical ▪ Metal leaching at neutral pH. Developing guidelines and principles ? by whom? MEND? MAC? ▪ Metal leaching – more than geochemical. It is chemical and physical issues. Physical issues include retention time and preferential flow paths. Physical/hydraulic aspects is an emerging aspects and is quite challenging. As time progresses preferential flow path could change from the coarse to the fine materials based on moisture. This has an effect on the ingress of oxygen into the pile and subsequent changes to the water quality emerging from the pile. ▪ Physical issues warrant the understanding of what goes into existing piles to analyze. Opportunities exist when piles are moved to pits. A visual record could be kept. Lift sizes could play a role – presently 20 m lifts are used, what would be the effect of using say 2 to 5 m lifts to produces denser fill with lower air and water permeability. This is practiced in coal mines with their coarse coal wastes.
PROJECT TITLE: Developing the knowledge about: hydrogeotechnical behaviour of waste rock piles and developing the according models **DETAILS:** ▪ Hydraulic aspects of waste rock (moisture retention/permeability) in relation to circum-neutral drainage . ▪ Project could be using non-INAP companies that are moving waste rock into a pit.
PROJECT TITLE: Desulphurization **DETAILS:** ▪ Full-scale application of existing technologies. ▪ Sulphide removal – lots of work completed but the results vary greatly in terms of the benefits of sulphide removal. Need more experimental work to identify the differences obtained.
PROJECT TITLE: Literature search on case studies and application from a closure or life cycle perspective of dry stack tailings **DETAILS:** ▪ World wide review on advantages and disadvantages ▪ Dry staking of tailings. Filter presses are used to lower the moisture and the tailings are trucked to the pond and compacted (up to 10^{-7} cm/s obtained). The advantage is at closure the footprint is reduced because of the reduction in surface area used for the tailings pond. It can also be well blended in the surrounding environment – small rolling hill etc. A literature review was proposed to look at the advantages and the disadvantages for the life cycle approach for application in Canada. Cost perspectives will need to be reviewed as well. People questioned the climate issue but it was pointed out that it is currently used in Alaska. Also many applications were noted for warmer climates such as in South America (using conveyors).

APPENDIX G: DETAILED PROJECT DESCRIPTIONS - THEME 4

GROUP: BLUE
PROJECT TITLE: Effect of climate on predictions and closure options. No details.
PROJECT TITLE: Use of waste rock **DETAILS:** The project would involve research into the use of waste rock (low S) in road/rail beds, townsites, road cuts, geochemical implications off the mine site
PROJECT TITLE: Community relation guide or code of ethics **DETAILS:** Project is related to "Productive use of wastes" – Theme 3, BLUE group
PROJECT TITLE: Abandoned sites **DETAILS:** Specific technologies to mitigate past effects; good data collection is essential – this involves getting good data on downstream water quality, evaluating impacts over the long term, risk assessment – to ensure we get good value for the money.
PROJECT TITLE: Re-opening closed mines **DETAILS:** Advanced exploration and disposal of mine water wastes/implications of re-processing of tailings; these activities are not presently included in the MEND mandate and perhaps they should.
PROJECT TITLE: Revisit closure cost models **DETAILS:** This would affect the philosophy of closure and the value of closure Details: timing of closures, when to do progressive closure (and avoiding making hasty decisions), NPV models, case studies **OUTCOME:** review of existing models and possibly a new model **The following project was grouped under this Project Title:** **PROJECT TITLE: Planning for closure from conceptual design to decommissioning** **DETAILS:** Net Present Value model appropriate
PROJECT TITLE: Case histories **DETAILS:** This should include a discussion of a definition for long term; what may need to be done is to examine the biology of sites so we can see what happens after water covers are put into place. Details: collating information and making sure that it is accessible to the public and academics Outcome: understanding of long-term performance of technology **The following projects were grouped under this Project Title:** **PROJECT TITLE: Enhancing/facilitating access to post-closure monitoring data** No details. **PROJECT TITLE: Synthesize monitoring data from multiple sites to evaluate closure technologies** **DETAILS:** Make sure data is accessible to the public and academics

GROUP: BLUE, Continued

PROJECT TITLE: Finite post-closure methods technology
DETAILS: The goal is to return mine lands to useful purposes/make it productive again. Discussion on the definition of "walk away", is this a reality? In the long-term the management plan goes from managing oxygen to managing water. It was also felt that we should not close the door on options that may not be favoured by the regulators but may make some scientific sense (e.g. deposition in natural basins)
Details: decrease 'active' management, provide a regulatory framework, and continue investigation of sub-aqueous disposal (non-engineered)
OUTCOME: Sustainable use of mined lands

The following projects were grouped under this Project Title:

PROJECT TITLE: Compilation of progressive reclamation works
No details.

PROJECT TITLE: Finite post-closure maintenance/management
DETAILS: Natural mimicry, etc.

PROJECT TITLE: Plant succession on reclaimed tailings ponds
No details.

GROUP: YELLOW

PROJECT TITLE: Public awareness of ARD – prepare educational tools on ARD
DETAILS: Research would include:

- The public needs to understand issues related to ARD but does not need or want the detailed technical material
- Target for general public and students
- Would build capacity within communities
- Material should be peer reviewed or derived from multi-stake holder involvement (need a balanced view and make sure it is right)
- MEND web site would be a good vehicle for this transfer
- MABC education kits are good examples of this transfer for students, but lacks good environmental section

PROJECT TITLE: Investigate new approaches to fund research on abandoned sites
DETAILS: Research would involve consideration of the following:

- Currently a shortage of funds to complete work on abandoned sites
- Phase 1 – devise new approaches to generate funds
- Phase 2 – implement approaches
- The Ontario program on sand & gravel is a good example
- Should link to Abandoned Mines Initiative

PROJECT TITLE: Investigate alternative financial assurances
DETAILS: Research would include:

- Industry using banks (letter of credit) to finance long term liabilities for ARD generating sites
- If industry would put annual cost of letter of credit into a trust fund then could build up a fund to deal with abandoned sites and still cover liability to sites
- Need financially stable companies so that risk of drawing from the fund in the early years would be low
- Short term – evaluate a range of feasible mechanisms
- Long term – recommend implementation
- Practical program to address industry, public, and government needs
- MAC has provided a concept on this type of proposal

GROUP: YELLOW, Continued

PROJECT TITLE: Remediation of ARD at abandoned orphaned mines or closed sites

DETAILS: Research would include:
- ARD issues come up at closed sites
- Short term – analysis of frequency of occurrence
- Long term – use of guidelines for remediation
- Need adequate representation of sites
- Utilize work at operating sites
- Benefits – better understanding of degree and frequency of the problem with closed sites and a better understanding of the tools and technology for prediction

GROUP: ORANGE

PROJECT TITLE: Dust control from tailings impoundments and facilities
DETAILS: Controls and measures, etc.

PROJECT TITLE: Evaluation of non-sludge forming neutralization
DETAILS: Use of Mg-hydroxides, caustic soda and ammonia

PROJECT TITLE: Long-term efficiency of shallow water cover
DETAILS: e.g. effects of ice cover

PROJECT TITLE: Review technology for aquifer remediation
No details.

PROJECT TITLE: Risk in Canada is associated with regulatory evolution: getting mine permits implies that groundwater is a pathway not a resource
DETAILS:
- There are no regulations to control
- The process is much different in Canada than in the US

PROJECT TITLE: Develop alternative standards and procedures for assessing progressive closure vs. end of life
DETAILS: Consider financial, ecological, social, helath & safety, regulatory and policy issues

The following projects were grouped under this Project Title:

PROJECT TITLE: Progressive closure vs. End of Life Closure
DETAILS:
- What are the benefits?
- Justify the gains
- Is it cost effective? (especially in the context of sustainable development)

PROJECT TITLE: Alternative approaches to closure or reclamation in permafrost conditions to reduce sensitivity to climate change
DETAILS:
- Taking southern approaches and applying in the North
- This would represent a conservative approach

PROJECT TITLE: Develop and/or Review standard procedures and protocols for estimating reclamation costs
DETAILS: Make information available to the public

PROJECT TITLE: Getting Regulators and Operators agreeing to a procedure for giving back a site
No details.

PROJECT TITLE: Financing of closure
DETAILS: Options for financial assurance to allow mines to open
- Is it working?

GROUP: ORANGE, Continued

PROJECT TITLE: Develop and refine and apply optimal geochemical, ecological and geotechnical monitoring techniques for early warning for potential impacts at mine sites.
DETAILS:
- Geochemical, ecological and geotechnical (of dams)
- Preventive and as an early warning
- Readily accessible results
- Remote sensing

The following projects were grouped under this Project Title:

PROJECT TITLE: Monitoring to assess long and short-term assessment of MEND sites and technologies.
No details.

PROJECT TITLE: Orphaned and abandoned mine
DETAILS: Information re monitoring of conditions and problems

PROJECT TITLE: Dam stability (long-term)
No details.

PROJECT TITLE: Monitoring in the context of groundwater and surface water
DETAILS:
- Refine monitoring methods for early warning (esp. in context of waste rock piles and tailings drainage into groundwater)
- Need both ecological and geological
- Don't have as good of monitoring methods as we think we have

PROJECT TITLE: Remote monitoring methods
No details.

PROJECT TITLE: Dam stability
DETAILS:
- Need to monitor techniques, make information readily accessible
- New geochemical methods

PROJECT TITLE: Develop alternative standards and procedures for assessing progressive closure vs. end of life
DETAILS: Consider financial, ecological, social, helath & safety, regulatory and policy issues

The following projects were grouped under this Project Title:

PROJECT TITLE: Progressive closure vs. End of Life Closure
DETAILS:
- What are the benefits?
- Justify the gains
- Is it cost effective? (especially in the context of sustainable development)

PROJECT TITLE: Alternative approaches to closure or reclamation in permafrost conditions to reduce sensitivity to climate change
DETAILS:
- Taking southern approaches and applying in the North
- This would represent a conservative approach

GROUP: ORANGE, Continued

PROJECT TITLE: Develop alternative standards and procedures for assessing progressive closure vs. end of life

PROJECT TITLE: Develop and/or Review standard procedures and protocols for estimating reclamation costs
DETAILS: **M**ake information available to the public

PROJECT TITLE: Getting Regulators and Operators agreeing to a procedure for giving back a site
No details.

PROJECT TITLE: Financing of closure
DETAILS:
- Is it working?
- Options for financial assurance to allow mines to open

PROJECT TITLE: Identify and designate MEND (and other) study sites for critical evaluation, for publicly available study
DETAILS:
- As a publicly available study site
- Take sites that already exist and exploit as a study resource
- e.g. – Could be used for technology evaluations

The following projects were grouped under this Project Title:

PROJECT TITLE: Monitoring to assess long and short-term assessment of MEND sites and technologies
No details.

PROJECT TITLE: Orphaned and abandoned mine
DETAILS: Information re monitoring of conditions and problems

PROJECT TITLE: Ecological engineering projects to identify future needs
DETAILS:
- Groundwater contamination
- Natural mimicry

PROJECT TITLE: Abandoned sites
DETAILS:
- Usually regarded as a problem but may have value as a historic
- Designate some sites as museum sites
- Track results over time – ie. don't remediate

PROJECT TITLE: Identify MEND study sites
DETAILS:
- Are there designated MEND study sites
- Allows for validation of various models
- Also permits the collection of data in the long term

PROJECT TITLE: Post-operational alternatives to closure uses
DETAILS:
- Are there uses that would provide new or added value?
- Consider alternate or non-traditional uses

GROUP: RED
PROJECT TITLE: Progressive Reclamation
DETAILS: ▪ Practical methods and tools ▪ Part of operating management plan ▪ Look at case histories ▪ Economic/social benefits in staged reclamation **The following project was grouped under this Project Title:** **PROJECT TITLE: Design for closure** **DETAILS:** Design and progressive implementation for post-closure
PROJECT TITLE: Abandoned Mines **DETAILS:** ▪ Lost cost methods to mitigate impacts of Abandoned Mines ▪ Framework for assessment prior to mitigation ▪ Mt. Washington as example of mitigation done without complete assessment; groundwater table problems in long-term ▪ Issue of finance – operating mines have cash flow
PROJECT TITLE: Evaluation of ecological recovery for closed mines **DETAILS:** Determination of how effective mine rehabilitation has been **The following projects were grouped under this Project Title:** **PROJECT TITLE: Monitoring of Post-closure measures** No details. **PROJECT TITLE: Metals uptake and vegetation** **DETAILS:** Adverse ecological impacts that mitigate effectiveness **PROJECT TITLE: Technical capacity within community to manage decommissioned sites with respect to geochemistry** No details.
PROJECT TITLE: Development of Innovative Usage of reclaimed mine sites **DETAILS:** e.g. – Golf course
PROJECT TITLE: Evaluation and communicate long-time closures **DETAILS:** ▪ Related to geochemistry ▪ No information coming from sites closed years ago
PROJECT TITLE: Remote sensing **DETAILS:** ▪ Who, what, why, when, where, how ▪ Some discussion on what remote sensing means ▪ Geophysical techniques (EM surveys)
PROJECT TITLE: Groundwater rebound – post-closure **DETAILS:** Pits filling up with water; measure, monitoring over time
PROJECT TITLE: Development of innovative and cost effective means to address clogged drains **DETAILS:** ▪ Dam monitoring tools/technical methods – maintenance ▪ Innovative measure to mitigate mounding/pooling of water in tailings dams due to clogged drains
PROJECT TITLE: Post-closure management of heap leach sites **DETAILS:** Limited number of sites affected
PROJECT TITLE: Information to connect post-closure effluent concentration to long-term loading **DETAILS:** Monitor change in contaminant loading

GROUP: GREEN
PROJECT TITLE: What are the fundamental parameters that need to be monitored for the closure mechanism that has been chosen and what tools/methodologies should be used to monitor these parameters? **DETAILS:** Protocol for long-term monitoring and/or closure. ▪ What to monitor, frequency ▪ What to report to regulators. Monitoring of key parameters for various closure options. Need to develop a methodology to measure performance indicators for the selected option. This could be the subject matter of a future workshop.
PROJECT TITLE: Workshop for technology transfer to professionals and industry. **DETAILS:** ▪ Workshop for building technical capacity within communities. ▪ Building technical capacity within communities to examine perpetual care of ARD/ML mine waste both for new and existing mines. ▪ Community education - Workshops in areas of controversial mines
PROJECT TITLE: Checklist for post-closure situations **DETAILS:** Post-closure monitoring- check list monograph ▪ Water quality ▪ Physical stability ▪ Vegetation ▪ Treatment Post-closure monitoring/management of the sites. There are site-specific requirements (e.g. climate) that need to be addressed, also regulatory. (IH) ▪ Suggested the preparation of a "monitoring monograph" that would identify the different requirements for each jurisdiction and a time scale associated with each parameter (e.g. surface erosion, vegetation). It would list all the items required that could be used by site personnel. Designers and regulators could make use of it. ▪ It could be referred to as a "checklist" of what needs to be examined.
PROJECT TITLE: Developing and identifying a structure that will manage the Canadian mining wastes for the long term. **DETAILS:** ▪ If "walkaway" is not possible. What are the elements of the alternative: o Institutional control o Central waste management organization. ▪ The need to have an entity that would be used to manage mining waste in the future was proposed. This group would be very active and would be responsible for the management of the closed sites using the money received from the individual companies (e.g. bonds, security deposits). This task is currently the responsibility of the mining companies. ▪ It was pointed out that the federal government adopted this approach for the management of used nuclear fuel through the creation of a separate Waste Management Organization funded by waste producers. Bill C-27 is expected to be passed this summer, requiring waste owner to setup the new waste organization.

APPENDIX H: GENERAL ISSUES RAISED DURING BREAKOUT SESSIONS

GROUP: BLUE

GENERAL COMMENTS:

Additional issues that should be considered are:

- Sustainable development
- Climate change (what is the effect of climate change on all of the closure options now being implemented (e.g. water covers, permafrost, etc.). What is the effect on currently used models?)

GROUP: YELLOW

GENERAL COMMENTS:

No additional comments provided

GROUP: ORANGE

GENERAL COMMENTS:

The group developed a list of issues that could be considered in all (or most) projects. The list included:

- Reporting and communications – internal and external
- Documentation/archiving
- Cost/benefit analyses (cost effective practices)
- Risk assessment
- ISO 14001 EMS approaches
- Case studies on already accepted technologies – model water quality over time (not only water)

The group also noted that duplication of research is not necessarily a bad thing, especially when conducting site-specific research.

GROUP: RED

GENERAL COMMENTS:

The group included a discussion of the following:

- A gap analysis could provide an opportunity to determine whether or not further research has added value
- MEND has been successful – the cost has been matched by benefits
- Regulations can be more rigorous – does the cost of solving these issues outweigh the benefits?
- An analysis of benefits and risks of technologies in civil societies would be beneficial (multiple account analysis of MEND tool kit)
- An overriding principle of research includes the need to conduct field trials before mine scale trials. Sufficient data is needed in order to proceed to large scale – including research related to wetlands. The trial will provide tools that can then be applied in the field.
- Water recycling and reuse was suggested – but this is not a challenge for MEND as this process occurs in the mill. The QC government has asked mines to do this for years.

GROUP: GREEN
GENERAL COMMENTS: ▪ Theme 1 focuses on geochemistry, but it should also look at the physical side of waste. Hydrology, physics and geology should be integrated, and *in situ* performance measurement strategies should be expanded and refined ▪ Modelling is important, but in many instances the models do not include all necessary the variables and relationships to produce accurate results. Models are good at providing recommendations in terms of the possible trends, but not the precise results. Built-in assumptions need to be rationalized, and the background data used to form models needs to be refined and verified if confidence in the results is to be improved. ▪ Environment Canada is developing a Mining Code of Practice. The process will be open to consultations, and will be based on best available technology. ▪ Social elements should be included in the risk assessment process. Individuals with social studies backgrounds should be included in the risk assessment team, and messages should be effectively communicated to the public. ▪ Implications of climate change need to be further researched.