Giant Mine Arsenic Trioxide
TECHNICAL WORKSHOP

PARTICIPANTS WORKSHOP MATERIALS

June 22, 23, 24 1999
Yellowknife NWT

Explorer Hotel

Department of Indian Affairs
and Northern Development

Table of Contents

Giant Mine Arsenic Trioxide Technical Workshop
Preliminary Evaluation Criteria and Matrix
Information Package
Workshop Agenda Item #5

DEFINITIONS IN THE CONTEXT OF THIS MATRIX:

Proven Technology: A technology which has published data that shows the technology can be run at a production scale.

Permanent Solution: A treatment for Arsenic Trioxide which will remove the arsenic from the Yellowknife biological system.

Environmental Conditions: Those conditions which predominate in Yellowknife such as low humidity and extreme range in yearly temperatures (from high 20EC to low - 40EC).

End Product: The Arsenic product which is generated by the process.

Level of Confidence: The confidence held by experts in the field in the design with respect to reliability, stability and efficiency.

Data/information: Any data collected in testing, research or operation of the process.

Reagents: Any material inputs required to complete the process.

Displacement/Disruption: Any actions which change the natural features of the area to any degree.

Capital Costs: All costs from the time that the project received Environmental Assessment approval through to the end of commissioning. Includes design, procurement, construction and commissioning.

O & M Costs: Operation and Maintenance: the cost of maintaining production from commissioning until the As_2O_3 is consumed through the process.

Closure Costs: The cost of decommissioning the plant once production has ceased and completing such works as to verify the closure does not pose a residual liability.

JUSTIFICATIONS:
Minimum performance criteria:

Why is it important that the technology be proven?
- Roughly 20 years of technology development has gone on
- There are proven technologies that are currently used to address this issue in other locations. Some of these have over 5 years of production records
- Need to move forward, toward a solution.

Why does the solution need to be permanent?

- Need to eliminate problem succession. This workshop is to work towards the final solution. Intermediate steps, although important in the overall management, are not the focus.

How did you arrive at the number 50 years to completion?

- 2 years to develop a complete project description.
- 2 years for E.A. process.
- 2 to 3 years design and construction.
- 20 to 25 years production.
- 2 years decommisioning.
- 35 years - rounded to 50.

Comparative Criteria:

Risk

Where does the data/information come from? How can we trust it's credibility?

Order of Confidence from greatest to lowest: 3rd party, independent, published data, proprietary data.

Service

Why does the process need to be flexible?

Feedstock will change as it will come from both the vaults and the mill process at the mine. Vault content has been shown to vary widely and there are head grade changes.

Why is it important that this process replace the roaster?

- To prevent the creation of more As_2O_3.
- Increase the likelihood of Giant site sale and future operation
- Removes As_2O_3 / SO_4 air emissions as side benefit.

Why is the recovery level of Arsenic and Gold important?

- Au recovery is reported to be worth $25million
- Additional $ recovery may be possible as head grades in old stopes are higher than the current production head grades.
- Removal of 100% of As_2O_3 impossible - but we need to move towards this.

Cost

Why is cost a factor? Shouldn't we be trying to clean up the arsenic, no matter what the cost?

Yes, however, where 2 or 3 competing technologies can provide a permanent solution, it is imperative that the socioeconomic factors be taken into account. Waste of money, either government or private, does not add to the reliability or security of the process. We need to find the *best value solution* not the most expensive or the cheapest solution.

SCALING FACTORS:

Risk

What level of confidence is there based on the data/information regarding design?

High: High level of confidence in data available based on a proven record of 5+ facility years of operation
Information regarding design has been widely proven on the full scale commercial industrial process applied on the same streams and in the similar environment
A data base containing full set of design data is in existence and is in compliance with regulatory (licencing) reporting

Moderate: Limited confidence in data available, based on a record of 1-4 years of operation
Design information is proven, but with certain modifications and/or process restrictions
Limited design data are available

Low: Little confidence in data available, based on a record of less than 1 facility year of operation
Unproven information. Process was not used for the same streams and/or in similar environment
Process was never fully developed to a commercial production scale in the past
Lack of certain design data (data gaps)

What is the level of safety for workers during normal and upset conditions?

High: Exposure expected during both normal and upset conditions is minimal or limited and controllable
Exposure through contact only
Automatic control eliminates risk
Regular maintenance requirements and conditions do not pose a risk to workers safety

Moderate: Exposure expected is substantial
Exposure during normal operating conditions is limited and controllable, but during upset conditions is substantial or unpredictable
Exposure through chemical hazards (by contact, inhalation, ingestion and noise)
Risk is mitigable with effective installation and operational housekeeping measures, including hygiene and PPE, adherence to certain procedures, and with education/training

Automatic control partially eliminates risk
Regular maintenance requirements and conditions pose a moderate and mitigable risk to workers safety

Low: Exposure expected during either normal or upset operating conditions is high and uncontrollable, or unpredictable
Exposure through chemical (by contact, inhalation, ingestion, noise) and physical hazards (temperature, pressure) through breakdown of equipment
Automatic control does not eliminate risk
Regular maintenance requirements and conditions pose significant risk to workers safety, or are unknown

Service

What reagents are required, what is the source of these reagents?

High: Quantities of all reagents required are significantly less than the quantity of As
Reagents are readily available or relatively easy to obtain
Availability of reagents in the future is not expected to differ from their current availability, and is certain and predictable
Providing of reagents in sufficient quantities is not associated with significant difficulties and costs
No reagents are required

Moderate: Quantity of at least one of the reagents required is comparable with the quantity of As
Availability of reagents is limited
Availability of reagents is likely to decrease in the future
Providing of reagents in sufficient quantities is associated with moderate difficulties and costs

Low: Quantity of at least one of the reagents required is significantly higher than the quantity of As
Reagents (in sufficient quantities) are not easily available
Availability of required quantities of reagents in future is uncertain or unknown
Providing of reagents in sufficient quantities is associated with high costs or is difficult

What is the level of flexibility of the process to changes in feedstock quantity and quality?

High: Good flexibility (or process insensitivity) to fluctuation in both feedstock quantity and quality
Process operates at 0-100% of design range

Moderate: Moderate sensitivity (some restrictions/problems) to fluctuations in feedstock

quantity and quality
Process sensitivity to variations in feedstock quantity but not quality and vice versa
Flexibility is achievable with reasonable modification of the process (acceptable trade-offs)

Low: Process is highly sensitive (serious restrictions/problems) to variation in feedstock quantity and/or quality
Flexibility is achievable by serious modifications of the process (non-acceptable trade-offs)
Poor flexibility over design range
Flexibility of the process to changes in feedstock quantity or quality is not known

What is the level of recovery of arsenic and gold for market?

High: Over 80% recovery of both

Moderate: Between 50% and 80% recovery of both
Less than 80% recovery of Au and more than 80% recovery of As

Low: Less than 50% recovery of both
No recovery of either As or Au
Level of recovery of either As or Au is unknown

How expediently would this process eliminate the As_2O_3 within 20 years?

High: The most (80, 90%? - depending on the process conversion rates) of As_2O_3 is converted to a less soluble, environmentally inert form that does not require specific storage conditions
Small quantity of residue containing As and/or other contaminants requiring disposal is left behind (less than 10, 20% of initial volume?)

Moderate: Limited amounts of As_2O_3 are converted (50-80%?)
Limited quantities of residues requiring disposal are left behind

Low: Small amounts of As_2O_3 are eliminated (less than 50%?)
Big quantities of residue containing contaminants (including As) requiring disposal are left behind
No As_2O_3 is eliminated
Expedience of elimination of As_2O_3 is unknown

Impact

Is the volume of the stored end product material minimal?

High: The volume of the stored end product material is smaller than the current As_2O_3 volume

Moderate: The volume of the stored end product material is comparable with the current As_2O_3 volume

Low: The volume of the stored end product material is larger than the current As_2O_3 volume

What number of jobs would be annually created (employment impact)?

High: Continual employment for a large number of people of all educational profiles
More than a thousand person years of employment

Moderate: Intermittent employment of a large number of people
Employment for smaller number of high profile workers
Between a hundred and a thousand person years of employment

Low: No new employment provided
Short term duration (during construction and start-up) of high level of employment, followed by a continual employment of a small number of people
Less than a hundred person years of employment
Employment impact is unknown

Costs

What are capital costs?

High: Costs Less than $10,000,000

Moderate: Costs are between $10,000,000 and $50,000,000

Low: Costs are more than $50,000,000

What are O & M costs?

High: Costs Less than $1,000,000 per year

Moderate: Costs are between $10,000,000 and $50,000,000 per year

Low: Costs are more than $50,000,000 per year

What are closure costs?

High:	Costs Less than $1,000,000
Moderate:	Costs are between $1,000,000 and $5,000,000
Low:	Costs are more than $5,000,000

Agenda Item # 1: Overview of Arsenic Trioxide Management at Giant Mine and the Chronology of Events Related to the Work Completed to Date on Arsenic Trioxide Management Practices and Options.
Presenters: Rick Allan, Neill Thompson, John Gale.

Presentation Abstracts:
Rick Allan - Giant Mine: History and Status of Arsenic Trioxide Management

Since the first production of arsenic trioxide bearing dust, resulting from the refining of refractory ores, Giant Mine has constantly re-evaluated and updated it's arsenic trioxide disposal practices.

With the implementation of underground arsenic trioxide storage in the 1950's, the giant Mine was recognized as providing an environmentally sound disposal concept. This plan included placing the material underground, in specially designed storage chambers, as a final disposal procedure. The arsenic trioxide storage areas would be isolated by bulkheads and permanently frozen to minimize the potential for the material to leach into the groundwater.

With a better understanding of arsenic chemistry, mine conditions, and emerging technologies it is apparent that the continued practice of underground storage is not a completely risk free disposal method.

The history of the underground storage practice and the status of the storage chambers are described, along with a general outline of future options for permanent disposal.

Neill Thompson - Chronology of Events Related to Work Completed on Arsenic Trioxide Management Practices.

Since 1997 the Department has been quite actively collaborating on a large amount of projects to assess the options for managing the arsenic trioxide stored underground at the Giant Mine. The main areas of focus are: current underground conditions, extraction methods, upgrading/re-processing the material to a commercial product and converting it into an environmentally stable material. Work has been conducted by the Department and in conjunction with other government agencies, consultants, the company itself, academics and mining and industry experts. To date the Department has spent approximately $750, 000 on 18 projects.

This work undertaken provides benefits in two ways: firstly, it provides the government, in it's role as the regulator, with information independant of the company's to determine if what the company is proposing is valid; and secondly, it furthers the general state of knowledge on arsenic trioxide management so that collectively more informative decisions can be made.

The presentation will briefly describe the types of projects undertaken.

John Gale - Hydrogeological Assessment of the Giant Mine and Arsenic Migration: Progress and Plans

A three-dimensional, numerical, groundwater flow and transport model of the Giant Mine is being developed by Fracflow Consultants Inc. as part of the *Giant Mine Arsenic Trioxide Management Strategy*. This model will be one of the important tools required to assess the engineering and scientific options that will be proposed for the management of arsenic trioxide dust at the Giant Mine. Environmental impacts will likely occur even if the majority of the arsenic trioxide dust is extracted from the underground storage chambers. Due to the physical/chemical nature of the dust and the condition of the storage chambers, extraction may not be successful in recovering all of the waste material, based on discussions at the previous Arsenic Trioxide Management Workshop. The residual fraction of the arsenic dust may be a significant quantity and is regarded as a significant potential source of long-term groundwater contamination in the Giant Mine area.

The Giant Mine is located at the south end of the Baker Creek Watershed. The watershed is approximately 28 km long, it has an average width of about 4.5 km, and a total surface area of approximately 126 km^2 based on the HYDAT data (Environment Canada, 1996). The total mean annual precipitation recorded at Yellowknife airport is about 270 mm (an adjustment for gauge under catch increases this amount to about 340 mm). Basin-wide evapotranspiration is estimated to be 200 mm per year; small lake evaporation is about 400 mm per year; and surface runoff is about 46 mm (± 36 mm). The amount of precipitation that actually recharges the groundwater flow system is estimated to be 62 mm per year (± 40 mm), or 18 to 22% of available precipitation, indicating a dynamic groundwater flow system.

The flow and transport model is being used for evaluation of the current and post-mining groundwater flow patterns at the mine site, identification of the potential pathways and migration rates for dissolved arsenic leaking from the underground storage chambers, identification of the surface discharge areas for dissolved arsenic (i.e., when, where, and how much arsenic will be discharged), and evaluation of the effectiveness of proposed measures to manage and mitigate this problem. The flow and transport simulations will provide critical information for determining if the arsenic trioxide dust will be left underground or, if it is to be removed, what would be the tolerable amount of residual arsenic that could be left behind in the chambers.

Hydro-geological investigations conducted by the study team have identified high concentrations of dissolved arsenic and other chemicals in borehole seeps located about 90 m (300 feet) below some of the oldest storage chambers (B-Series) in the mine. It is highly likely that this chemical contamination has originated from the storage chambers. At the present time, it appears that dissolved arsenic and its associated chemicals are being contained and controlled by the mine's de-watering and surface treatment system.

Based on the conceptual hydro-geological model of the mine when it closes and floods, continued leakage of arsenic and other associated contamination from these chambers into the groundwater flow system will probably result in the migration of this contamination to discharge areas that will develop along the Baker Creek valley, and near the A2 open pit in particular. Consequently, mitigation by removal and treatment should necessarily include remedial measures to address the groundwater contamination issue, including the ongoing preliminary modelling (Phase 1), planned field activities (Phase 2), and final model simulations (Phase 3).

<u>Presenter Bios:</u>

Neill Thompson graduated with a Bachelor of Science degree in Geology from the University of Manitoba.

He worked for eight years in environmental management in the mining industry in northern Saskatchewan. During that time he experience a broad range of environmental activities associated with construction, commissioning, operation and reclamation at the mine.

Neill has spent the last twelve years in the Northwest Territories, first with the GNWT and later with DIAND.

In his ten years with the GNWT Neill was with the Environmental Protection Division of what is now the Department of Resources, Wildlife and Economic Development where he attained the position of Assistant Director. Through this period Neill was involved in a number of regulatory initiatives and national level committees relating to hazardous waste, contaminated sites and the transportation of dangerous goods. He was also involved in the environmental review and development of water licenses through the NWT Water Board's Technical Advisory Committee.

Neill has been with Water Resources Division of DIAND for over two years and is the Head of the Regulatory Approvals Section. The Section has responsibility for providing technical support to the NWT Water Board by conducting environmental screenings, undertaking technical project reviews and developing water licenses. During this time he has also developed a number of project teams to address water resource related issues. He is currently involved in the Department's team evaluating arsenic management options at the Giant Mine.

Neill is also active in the area of land reclamation. He is a national Director for the Canadian Land Reclamation Association and is the CLRA representative on the International Association of Land Reclamationists.

John Gale, the President of Fracflow Consultants, is a Hydrogeologist/Geological Engineer whose expertise covers a broad spectrum of environmental and geological engineering, with specialization in the hydrogeology of thin overburden over fractured-rock systems, contaminant hydrogeology, and flow system analysis especially in mining applications. Dr. Gale has had over 25 years experience in conducting and supervising both small and large scale projects and has authored and/or co-authored over 150 scientific and engineering publications (list is available on request). Over the last 22 years, Dr. Gale has taught physical and contaminant hydrogeology at both the undergraduate and graduate levels, at both the University of Waterloo and Memorial University, and contributed to a number of short courses, seminars and lectures in fractured rock hydrogeology in a number of institutions in more than 15 countries. This work has also included the supervision of the thesis research and thesis preparation for approximately 30 undergraduate honours students, about 20 MSc students, and about 5 PhD students. Dr. Gale has been the project manager or the principal investigator for a range of projects, in which environmental site and groundwater investigations have been an integral part of the work, including the international Stripa Project, the Voisey's Bay Baseline Hydrogeological Study, the CVRD Minewater inflow study, the Makinson's NCSRP PCB project, the Gander NCSRP hydrocarbon DESRT project, and a host of other environmental and hydrogeological projects.

EDUCATION AND CERTIFICATION

- Ph.D. (Engineering Geoscience), **University of California at Berkeley**, Berkeley, Ca., U.S., 1975.
- M.E.Sci. (Engineering Geoscience), **University of California at Berkeley**, Berkeley, Ca., U.S. , 1973.
- M.Sc. (Hydrogeology), **University of Western Ontario**, London, ON , 1971.
- B.Sc. (Geo.) and B.A. (Ed.), **Memorial University of Newfoundland (MUN)**, St. John's, NF , 1968.
- Professional Geoscientist/Engineer, **Association of Professional Engineers of NS, Association of Professional Engineers and Geoscientists of NF, and NAPEGG, NWT.**

Agenda Item # 2: The Giant Mine Arsenic Management Strategy Being Led By The Federal Government: Commitment and Action
Presenter: Dave Nutter

Presentation Abstract:

There is a significant amount of highly toxic As_2O_3 stored undergound at the Giant Mine in Yellowknife. DIAND's number one priority is safeguarding public health and safety, and securing the environment, ensuring that this As_2O_3 does not adversely impact on the lives of residents in the Yellowknife region.

The Giant Mine is still in the hands of the private sector, and it is their responsibility to ensure that all laws are complied with. However, should the property be abandoned, DIAND, with other federal and territorial agencies, will ensure that all necessary steps are taken to keep the As_2O_3 safely contained at the mine site until the best means of dealing with it over the long term is identified, assessed, approved and implemented.

DIAND's current role in the process leading to the implementation of a long term As_2O_3 management solution is that of a regulator. Strictly speaking, the development of this management solution is the private sector's responsibility. However, we all are well aware of the financial situation facing Royal Oak Mines Inc., the owner of the Giant Mine. DIAND believes that the public should not have to wait for this financial situation to be resolved before the As_2O_3 issue is addressed; rather, actions must be taken now to come up with the long term plan for dealing with the As_2O_3. For this reason, DIAND has taken the lead in identifying the problems associated with the As_2O_3 and finding the best long term solution. This week's technical workshop should make significant progress towards identifying that solution.

At present, the safest location to store the As_2O_3 is underground at Giant. It is securely contained there in vaults, and any leakage of contaminated groundwater is collected in the mine sumps and returned to surface for treatment.

It is important to choose the right solution, not just pick what seems obvious off the shelf. There are a variety of proven technologies or processes which have dealt and are dealing with As_2O_3 elsewhere in the world, including at the Con Mine in Yellowknife. However, each situation is unique, and Giant certainly is. The sheer volume of As_2O_3 and its location underground at Giant place this management problem in a very challenging category of its own. Given its location on the outskirts of a major community and its proximity to a large water body which serves much of the NWT, there is a high degree of public interest and, understandably, public concern.

We must ensure that the solution is the right one for the long term, primarily from the perspective of safeguarding the public's health and the environment. Also, because significant public expenditures may be required to deal with the problem, we must ensure a wise and effective use of public funds.

Finally, it is very important that the process of selecting and implementing the long term As_2O_3 management solution is a public one, so that the public accepts and supports this solution. An open and thorough environmental impact assessment can and will meet the need for public transparency and support. This process will be discussed more fully by speakers following me.

The speakers before me have reviewed the work undertaken to date by DIAND and Royal Oak, in

our attempts to fully understand the problems surrounding the underground storage of As_2O_3 at Giant. Over the past 18 months, DIAND has invested close to one million dollars in gathering information which has put us much closer to finding the best long term management solution. Over the next three days, we will learn about and discuss the merits of and challenges inherent in a number of As_2O_3 management options.

DIAND has developed a strategic framework and estimated time line for the actual implementation of the As_2O_3 management option which is ultimately chosen. The strategic framework consists of 6 components: Define the Problem; Develop Options for Solutions (to the problem); Complete the Project Description; Complete the Environmental Assessment; Complete the Regulatory Approvals, and Implementation. Each component is characterized by three facets: Technical; Policy and Communications, and DIAND has identified tasks which must be addressed within each of these facets.

For example, as part of developing options for long term As_2O_3 management, the technical facet includes the identification of all feasible options and their assessment against a standard set of evaluation criteria. We will develop these evaluation criteria at this week's workshop, and, through their application, be able to focus our attention on a short list of the most promising management options. This evaluation will also identify the knowledge gaps and show us where more research is required to confirm the most appropriate management solution.

DIAND estimates that at least 4 years will be required before we will see full implementation of a long term As_2O_3 management solution, and this is contingent upon the selection of this preferred option within the next 18 months. The following 2-3 years would be required to prepare a complete project description, submit this project proposal to rigorous environmental impact assessment and public review, and obtain the necessary regulatory approvals. Because this is a significant environmental issue within the community, DIAND is committed to a thorough public review of the proposed As_2O_3 management option before we will authorize its implementation. And, as we have seen recently with both the BHP and Diavik projects, this process takes time.

This week's workshop is a cornerstone of DIAND's commitment to developing a broad As_2O_3 management strategy. DIAND welcomes all participants to this As_2O_3 technical workshop and thanks you for your contributions towards the identification of a long term solution to the management of As_2O_3 stored at the Giant Mine.

Presenter Bio:

Education
BSc - Geology
MSc - Mineral Exploration

Work Experience
- 20+ years in private sector, involved in mineral exploration across Canada and overseas
- 9 years with DIAND, primarily responsible for federal role as manager of mineral development in the NWT
- worked in North since 1971; resident of YK since 1984
- recently focussed solely on federal interest in fate of Royal Oak properties in the NWT

Agenda Item # 3: Development of the Giant Mine Arsenic Trioxide Project Description: Objectives & Performance Standards, Environmental Review & Decision Making Processes. Presenter: David Livingstone

<u>Presentation Abstract:</u>

Objective: Find and implement a safe, permanent solution to the arsenic problem.

Performance Standards:
- proven technology
- acceptable risk (safety)
- minimum maintenance upon closure (permanency)
- cost-effective

Environmental Impact Assessment:
- what's the setting?
- what are the objectives of the project?
- what are the options available to achieve the objectives?
- what are the preferred options and why?
- what is the preferred solution and why?

Current Water Licence Requirements:
- detailed description of proposed disposal methods
- rationale for the preferred method
- risk assessment for the preferred method
- detailed description of contingencies
- implementation of schedule and costs
- detailed description of management of residual and waste materials
- detailed monitoring plan

The Steps:
- clear understanding of the current situation
- clear understanding of options for treatment
- ranking of these options, based on performance standards
- development of preferred option(s)
- development of preferred solution
- development of detailed project description, based on preferred solution
- development environmental assessment report
- preliminary screening
- referral to MVEIRB
- public review
- regulatory review
- implementation

Presenter Bio:

David is currently Director, Renewable Resources and Environment, for the Department of Indian Affairs and Northern Development in Yellowknife, NWT, where he has lived for the past ten years. His mandate includes regulatory responsibilities for water resources onshore and offshore in the NWT, the delivery of numerous environmental programs including the cleanup of contaminated sites and studies related to the long range transport of contaminants, the development and implementation of environmental management measures such as monitoring programs, the operations of the Taiga Environmental Laboratory and ensuring that the requirements of environmental legislation and the Canadian Environmental Protection Act are met by the department in the NWT. Prior to assuming his current position about five years ago, David held various positions in Indian Affairs and Northern Development, Fisheries and Oceans, and the federal department formerly known as Energy, Mines and Resources.

David was born in Red Lake Ontario and grew up in mining communities in Ontario and British Colombia. He holds a B.Sc. in Geology from the University of British Colombia and an M.A. in geography from Carleton University, is married and has two sons.

Agenda Item # 4: Environmental Impact Assessment Process, Criteria, Factors and Considerations to Ensure Public Health and Environmental Safety
Presenter: Heidi Klein

Presentation Abstract:

The guiding principles behind environmental impact review are: 1) To protect the environment from significant adverse impacts; and 2) To protect the social, cultural and economic well-being of residents and communities in the Mackenzie Valley.

The purpose of environmental assessment is to ensure that the impact on the environment of proposed developments receive careful consideration before actions are taken in connection with them, and to ensure that the concerns of Aboriginal Peoples and the general public are taken into account.

There are three steps to environmental assessment:

Preliminary screening

This step is completed primarily by regulatory authorities such as the Mackenzie Valley Land and Water Board. This small scale environmental impact assessment is meant to consider impacts on the environment. It's purpose is to decide if there might be significant adverse impacts or public concern.

Environmental Assessment

This step is completed by the Mackenzie Valley Environmental Impact Review Board, which is an independent, quasi-judicial board. This board is made up of the following members: Gordon Lennie (Chair), Bertha Rabesca, Len Colosimo, Dennis Bevington, Charlie Snowshoe, and Cindy Kenny-Gilday.

Factors to be considered in this step include:

- Purpose
- Alternative means that are technically and economically feasible
- Need for a follow-up program
- Capacity of renewable resources likely to be significantly affected to meet existing and future needs
- The impact on the environment including malfunctions or accidents, and any cumulative impacts that are likely to result from the development in combination with other developments
- The significance of any such impacts
- Comments submitted by members of the public
- Any other matter such as need or available alternatives which are considered relevant

Environmental Impact Review

Impact on the environment means any effect on land, water, air or any other component of the environment, as well as on wildlife harvesting, and includes any effect on the social and cultural environment or on heritage resources.

Some good practices to follow in Environmental Impact Assessment are:

- Integrate development design work with environmental planning
- Improve scoping and start baseline studies early
- Start public consultation and involvement early
- Provide and make available to the public written reasons of any decisions or
- recommendation.

Presenter Bio:

Agenda Item # 5: Framework for Assessing the Options: Preliminary Evaluation Criteria & Comparative Matrix.
Presenter: Gary Strong

Presentation Abstract:

In order to assess the viability of the options available, a careful evaluation must be completed. This evaluation will be completed with the aide of a comparative matrix. Evaluation criteria for this matrix have been developed which address critical issues such as risk, service, impact and cost. These criteria will be applied to each option in turn whereby they will be ranked in order to eliminate those options which are not be feasible and to explore those options which are.

Presenter Bio:

Mr. Strong is the Managing Partner for Dillon's Yellowknife operation. Gary is a civil engineer with over 14 years experience in the planning, conceptual design, detailed design, and construction of municipal and industrial infrastructure projects. During his 9 years in the NWT, Gary has continually assembled highly qualified and dedicated project teams to meet the diverse requirements of the multidisciplinary projects that he has undertaken. As a project manager, Gary has been involved with the regulatory approval process on a number of occasions, and understands the current regulatory framework that governs projects in the NWT.

Gary's experience in the north also includes a number of projects for the northern mining industry, both with respect to the regulatory agency approval process and for detailed design of infrastructure components. Issues addressed in these projects include: stack emissions, tailings pond construction, facility monitoring for permit compliance, process water infrastructure design and construction. Gary understands the various aspects of the mine development and operations, and the activities/operations that are undertaken in the construction and operational phases of the mines. Some projects he has been involved with include:

- **Royal Oak Mine Arsenic Trioxide Workshop, 1997 -** this consisted of the development and implementation of a workshop to identify the major issues with the management of arsenic trioxide at the Giant Mine Site in Yellowknife, NWT.

- **Royal Oak, Stack Emissions, Yellowknife NWT** - This work consisted of three project phases completed for two clients. Phase 1 was completed for Government of Northwest Territories, Environmental Protection Division, and consisted of the compilation of all ambient air emission standards for Canada. Phase II, completed on behalf of Royal Oak and GNWT, Environmental Protection Division, consisted of air modelling for the Roaster Stack at Giant Mine in Yellowknife, NWT. Phase III, completed for Royal Oak, assessed the feasibility of various process modifications to meet the requirements of the regulatory agencies with respect to SO_2 emissions.

- **Mir-Mar Con Mine Tailing Pond Water Licence Compliance -** On an annual basis Dillon, in association with EBA Engineering, completes the inspection and monitoring of the tailings treatment decant pond system. This assignment has spanned several years, and upgrades to the facility have been under taken during this period.

- **Environmental Baseline Assessment, Zach Pond, NWT** - Completed for a development company, Dillon completed sediment and water chemistry, limnology, and lower trophic level data collection and analysis of a pond prior to exploratory drilling. The data collected ins included in the environmental baseline work for the development.

- **Niven Lake, Yellowknife NT.** Back ground documentation was developed to address concerns, and identify mitigation actions for an old sewage and solid waste facility in Yellowknife. Through the regulatory process, the site was eventually deregulated, and the area is currently developing as a subdivision.

Presenter: Andy Swiderski, Jim Micak

Presenter Bios:

Andy Swiderski has over twenty years of interdisciplinary research, planning, and management experience in both the private and public sectors across Canada. Twelve years of internal consulting experience at senior levels in the public sector, including central agency operations, in the areas of strategic planning, policy analysis, legislation, research design, financial management, and organizational design. Experience profile includes participation in and management of numerous projects ranging from research and policy analysis, survey research, strategic planning, capital planning, resource assessment, program design, organizational design, and human resource management.

The public sector experience is complemented by seven years of project planning and management in private sector consulting firms. University teaching, research in community and regional/northern planning and development, resource economics, Aboriginal comprehensive claims, devolution and self-government complete the qualification profile.

Education

- PhD Development Planning, York University, Toronto (1989)
- MA Community Planning University of Alberta, Edmonton (1985)
- BA Urban & Environmental Studies York University, Toronto (1980)
- P. Dip. Community & Transportation Planning Sheridan Technical College, Toronto (1977)

Experience

- Partner, Terriplan Consultants Ltd., Yellowknife (1998 - present)
- Associate, Terriplan Consultants, Yellowknife (1996 - 1998)
- Research and Policy Advisor, Renewable Resources, Government of the NWT, Yellowknife (1992 - 1996)
- Research Advisor, Commission for Constitutional Development, Yellowknife (1991 - 1992)
- Director, Management Services, Social Services, Government of the NWT (1990 - 1991)
- Policy Advisor, Priorities & Planning Secretariat, Department of the Executive, Government of the NWT (1989 - 1990)
- Assistant Superintendent, Municipal & Community Affairs, Government of the NWT, Baffin Region (1987 -1989)
- Teaching Assistant/Lecturer, Planning & Geography, York University (1986 - 1987)
- Senior Planner, Municipal & Community Affairs, Government of the NWT, Baffin Region (1984 - 1986)
- Senior Planner/Researcher, Yellowhead Regional Planning Commission, Alberta (1982 -1984)
- Design Planner, CEP Consultants, Alberta (1981 -1982)
- Technologist/Researcher, Lavalin Incorporated, Ontario, Quebec, Alberta (1978 - 1981)

- Planner, Hudson Elliott Inc., Ontario (1977 - 1978)
- Planning Technician, City of Oakville, Ontario (1976 - 1977)

Professional Associations

- Member of the Canadian Institute of Planners
- Alberta Association, Canadian Institute of Planners
- Ontario Professional Planners Institute

Jim Micak has over 25 years experience advising on complex and controversial issues. The focus of Mr. Micak's consulting practice is in stakeholder consultation, facilitation, conflict resolution, and environmental assessment. Jim possesses an Advanced Certificate in Environmental Conflict Resolution and Mediation from the Banff School of Management, taught by instructors from the Harvard University Negotiation and Mediation Program. Mr. Micak is a highly skilled facilitator, and has been responsible for decision-making processes ranging in size from 10 to 100 people, often dealing with extremely contentious situations and has successfully guided groups to resolve problems, identify solutions and arrive at consensus.

Jim has been involved in numerous stakeholder involvement programs regarding waste management, environmental issues, community and strategic planning, economic development, regulatory issues, and resources development. He recently was one of the lead facilitators for workshops for Ontario Hydro's review of it's strategy for long-term management of used nuclear fuel.

Of particular relevance is Mr. Micak's role as facilitator of Environment Canada's Strategic Options (SOP) process. He designed and guided a series of nation-wide multi-stakeholder consultations designed to identify options for management of toxic substances, and facilitated several Issues Tables. The Issues Tables had an 18-month mandate from the Minister of the Environment to follow a process and derive a series of recommendations. Participants included representatives of environmental groups, industries, trade associates, Federal and Provincial governments, aboriginal communities and international organizations. Mr. Micak was also involved in the design and delivery of the Facilitation and Consultation Skills training program in support of the SOP for approximately 100 middle management personnel for Environment Canada and Health Canada.

Recently, Mr. Micak was involved in a project for the U.S. EPA to facilitate a multi-stakeholder process involving Federal and State Attorneys General, senior environmental regulators, and representatives of environmental associations and Fortune 500 companies in assessing and developing innovative methods to re-structure and improve the way in which Environmental Audits could be conducted and used to measure environmental performance.

Jim was the chief facilitator for the Canadian Council of Ministers of the Environment multi-stakeholder nation wide workshop on the harmonization process for future definition of hazardous waste in Canada. He has also provided facilitation support to projects for the Ontario Ministry of Natural Resources (timber management EA), Laidlaw Waste Systems Ltd. (landfill), the Region of Niagara (waste management), the Region of Durham (sludge management), and the International Mineral and Chemical Company (site clean-up). Other clients include Citizenship and Immigration Canada, Health Canada, Ontario

Ministry of Environment, and CN North America.

Jim had provided process facilitation support across the North assisting DIAND, RWED, the City of Yellowknife, NTI and the Government of Nunavut, regarding community development and environmental issues.

Education

- Advanced Certificate in Environmental Conflict Resolution and Mediation, Banff School of Management, 1990
- Post-graduate Studies in Geography and Planning, University of Waterloo, 1977, 1978
- Bachelor of Environmental Studies (Honours), University of Waterloo, 1974

Selected Consultancies

- Facilitator for Mackenzie Valley Cumulative Impact Monitoring Program workshop
- Facilitator/mediator, NWT Power Corporation restructuring and organizational change
- Lead Facilitator for the Canadian Council of Ministers of the Environment multi-stakeholder workshop on the future definition of hazardous waste in Canada
- Lead Facilitator, Ontario Hydro Stakeholder Workshops - Review of Strategy for Long-term Management of Used Nuclear Fuel
- Facilitator, Health Canada's National Forum on Health
- Facilitator to Environment Canada's Strategic Option Process - Nationwide Issue Tables
- Facilitator, public consultation program Interim Waste Authority Ltd.'s Landfill Site Search Metro Toronto/Region of York
- Development of workbook and facilitation of seminars on emergency planning for recycling facilities and waste management operations, Office of the Ontario Fire Marshal, Ministry of the Solicitor General and Correctional Services
- Facilitation of focus groups, Northwest Territories Constitutional Working Group
- Peer Review of AECL's Public Consultation Program - High Level Nuclear Waste Disposal EIS
- Project Manager/Facilitator, City of London Vision '96 Community Consultation Program
- Facilitator for Ontario Ministry of Natural Resources' Megisan Lake Class Environmental Assessment Criteria Workshop
- Public consultation and issue assessment to Region of Niagara Re: waste management jurisdiction transition study.
- Workshop /Process Facilitator for the U.S. Environmental Protection Agency's Environment Audit Program Review
- Issue Management and Environment Conflict Resolution, International Mineral Corporation
- Public Consultation Program Design, Canadian Coast Guard - Boating Safety Regulation
- Facilitation, Consultation Skills and Effective Environmental Decision-making Training Program for Environment Canada
- Strategic Advisor and Process Facilitator to Environment Canada Strategic Options Process regarding future management strategies for priority toxic substances
- EA Process Advisor and Process Facilitator for the Region of Durham's sludge management project

Option # 1: Storage in Place
Presenter: John Brodie

Presentation Abstract:

1) EXISTING CONDITION
   a) vault geometry
   b) vault location to critical features, mine workings, pits, creeks, overlying topography
   c) accessibility
   d) arsenic trioxide condition from 1981 Geocon study
2) INFORMATION GAPS & STUDY REQUIREMENTS
   a) verify geometry and location of critical features
   b) develop options for improved accessibility
   c) sample arsenic for range of physical and chemical properties
3) STORAGE IN PLACE
   a) description of storage in place options
      i) pump and treat
      ii) natural re-establishment of permafrost and mine air freezing
      iii) grouting
      iv) preferential pathways
   b) preliminary assessment of pros and cons of storage in place options
4) POTENTIAL EXTRACTION METHODS
   a) description of potential extraction methods
      i) draw-point mining
      ii) clam shell mining
      iii) vacuuming
      iv) reverse-circulation drilling
      v) hot water washing
   b) preliminary assessment of potential residual remaining in chambers
   c) preliminary assessment of pros and cons of potential extraction methods

Presenter Bio:

John Brodie received the B.A.Sc.(1982) in Geological Engineering from the University of British Colombia. He is registered with the Association of Professional Engineers and Geoscientists of British Colombia, the Association of Professional Engineers, Geologists and Geophysicists, NWT, and the Canadian Institute of Mining, Metallurgy and Petroleum.

John is a geo-technical engineer with extensive experience in the environmental and decommissioning aspect of mines. He has been extensively involved in mine design, permitting and closure planning.This work has included: environmental liability assessment, site assessment and closure planning, control of acid rock drainage, design and construction of waste management facilities, and preparation of several manuals and guidelines pertaining to mine waste management and mine closure. He has been involved in over 40 mine closure liability assessments. Recently, his work has included studies for environmental liability transfer agreements for mines. He has published many papers on mine closure planning and reclamation. John wrote the guideline "Mine Reclamation In NWT and Yukon" and the accompanying RECLAIM cost estimating model.

His experience in reclamation assessments for northern mines has included work on 5 mines in Yukon (Mt. Nansen, Ketza River, Dublin Gulch, Western Copper, and Whitehorse Copper), several mines in N.W.T. (Giant Mine, Colomac Mine, Con Mine, Ptarmigan/Tom mines, Cantung Mine, and Ekati Mine), and several advanced exploration projects in N.W.T. and Nunavut.

Other positions John has held since 1983 are: Manager of Engineering, Reclamation Management Limited; Senior Geotechnical Engineer, Steffen Robertson and Kirsten (Canada) Inc.; Mine Geotechnical Engineer, Westmin Resources Ltd.

Option # 2: Solidification/stabilization
Presenter: Bill Cullen

Presentation Abstract:

The most common forms of arsenic that have been used, or suggested for use, for longtime storage of arsenic, are as follows: metallic arsenic, arsenic trisulfide, calcium arsenate, ferric arsenate, and the mixture sometimes called “ferric arsenate" that results from the co-precipitation of arsenate with ferric hydroxide. Vitrification of the dust (incorporation into a glass), or incorporation of the dust into materials such as cement, bitumen, and sulfur are other possibilities.

The mine dust is stored either in the form of a dry free-flowing powder or as a slightly damp and compacted solid, so the options are to handle it as such, or as a solution/suspension in water.

Options for treating aqueous solutions of the mine dust

- Reduction to arsenic metal (possibly electrochemical);. precipitation as calcium arsenate (requires oxidation and a source of calcium); precipitation as arsenic sulfide (requires hydrogen sulfide); precipitation with ferric hydroxide (requires oxidation and a supply, in excess, of an appropriate iron compound).
- The solution/suspension could be mixed into cement with or without prior oxidation.

Options for direct treatment of the mine dust

- Conversion to metallic arsenic (requires a reduction step, probably involving carbon and an energy source); conversion to arsenic trisulfide (possible new technology involving mine dust, pyrite, and energy); conversion to ferric arsenate (possible new technology involving mine dust, a source of iron oxides, and energy, or possibly by using an autoclave reaction as carried out at the Con Mine).
- Incorporation of the dust into glass (requires, at least, mine dust, sand, and energy)
- Incorporation of the dust into cement (requires cement), bitumen (requires bitumen), or sulfur (requires sulfur).

Some favorable results involving the incorporation of dust samples from the Giant Mine into cement, bitumen, and sulfur will be presented.

Presenter Bio:

Education

Ph. D. Inorganic Chemistry	1959	Cambridge University
M. Sc. Physical Chemistry	1957	University of New Zealand
B. Sc. Science	1955	University of New Zealand

Recent honors and awards

Fellow Royal Society of Canada 1993; Killam Research Prize, UBC, 1994; Killam Senior Fellowship, UBC, 1989; Presidents Service Award for Excellence, UBC, 1998.

Current research interests

Biogeochemistry of arsenic and antimony. Biodegradation of PAHs and PCBs in the environment.

Recent professional experience

1998-	Emeritus Professor	Chemistry UBC
1969-1998	Professor	Chemistry UBC
1995	Visiting Professor	Chemistry University of Graz
1995	Visiting Professor	De Montfort University
1989	Distinguished Visiting Professor	University of Adelaide
1994-present	Associate Editor,	Applied Organometallic Chemistry

Publications

About 350 to date most of which have been concerned with arsenic chemistry in one way or an other.

Studies of particular interest to Yellowknife residents

1. The interaction of microorganisms isolated from sediments of Baker Creek and Kam Lake, and tailings ponds, with arsenic.
2. Arsenic compounds in the plants and fish of the Yellowknife region.
3. The incorporation of arsenic containing mine dust in cement, bitumen, etc.
4. An environmental evaluation of the Miramar Con mine: A report commissioned by the Federal Department of Justice. Submitted in 1999 by the Environmental Sciences Group, Royal Military College of Canada, Kingston, Ontario, and the Environmental Chemistry Group, U. B. C.

Other relevant information.

Member of the US National Research Foundation Committee on arsenic in drinking water (1997-1999). Consultant for the US EPA on arsenic chemistry. Consultant for NATO on the destruction of chemical warfare agents.

Option #3: Autoclave
Presenter: Rod McElroy

Presentation Abstract:

Over the past 20 years, autoclave pressure oxidation has been developed into a cost-effective and widely applied technology for treatment of arsenical gold ores, concentrates and residues. Autoclave technology has advantages including:

- High gold recovery
- Concurrent stabilization of arsenic
- No atmospheric emission of sulphur dioxide or volatile metal oxides.

These features of autoclave pressure oxidation technology are relevant to the purposes of the workshop outlined in the invitation documents, particularly in regard to assessment of engineering and scientific options for management of arsenic trioxide at the Giant Mine.

To facilitate a general understanding of autoclave technology, this presentation includes:

- A brief history of the application of pressure oxidation to gold ores, concentrates and arsenical residues
- A summary of the process chemistry, with particular reference to arsenic residue stabilization
- A process flow sheet for the Con Mine Autoclave facility, for which arsenical residue stabilization was a key design feature
- Process performance data including residue environmental stability
- Brief discussion of hygiene, safety and maintenance aspects of autoclave operation
- Requirements for application of the technology to Giant Mine residues
- Overview of the applicability of autoclave technology for treatment/stabilization of Giant Mine arsenical residues

The specific "criteria" requested in the Workshop Presentation Guidelines are presented in point form as an Appendix (section 8.0), with reference to the text and published documents.

Presenter Bio:

Rod McElroy is a Senior Metallurgist with Fluor Daniel Wright (FDW) in Vancouver. In addition to work for the Con Mine, his autoclave leaching technology experience includes work on nickel-cobalt laterite projects, copper process studies and waste treatment designs. Prior to joining FDW in 1988, he worked as metallurgist and contract research manager for B.C. Research. His NWT experience includes management/execution of environmental studies for Nanisivik, Polaris and Pine Point Mines. He was educated at the University of Alberta (B. Sc., Hons.), McMaster (M.Sc.) and the University of British Colombia (Ph.D).

Co-Authors:

Wes Young is a Principal Process Engineer with Fluor Daniel Wright Ltd. in Vancouver. He has participated in a number of pressure leaching projects and studies involving zinc, nickel and cobalt, vanadium, uranium, copper, molybdenum, and refractory gold. His primary area of activity is hydrometallurgical processing. Prior to joining Wright Engineers in 1988, he held process engineering positions with Earth Sciences Extraction Company in Calgary, Saskatchewan Mining Development Corp. (now Cameco) in Saskatoon, and Gulf Minerals at the Rabbit Lake uranium operations. He received his B.A.Sc degree from the University of Toronto.

Brian Johnston is a Principal Process Engineer with Fluor Daniel Wright in Vancouver. Prior to joining FDW in 1994, he was employed by Falconbridge, Kidd Division, a major integrated metallurgical site located in northern Ontario. It includes the Kidd mine and concentrator, and a zinc plant and copper smelter. He was intimately involved with the installation of the Kidd zinc pressure leach plant from its inception. He has also been involved in the preparation of feasibility studies for mining projects in the NWT and Alaska. He holds a degree in metallurgical engineering from the University of British Colombia, and an MBA from Laurier University.

Option # 4: Sublimation (WAROX and El Indio)
Presenter: Serena Domvile

Presentation Abstract:

Two pyrometallurgical, selective sublimation technologies have been subjected to a conceptual level evaluation as optional methods of treating crude arsenic baghouse dust produced and stored at the Giant Mine, namely:

- *WAROX process*; and
- Process developed and implemented at El Indio, hereafter referred to as the *El Indio Process*

Both processes have been developed for the purpose of recovering contained metal values and producing a marketable arsenic trioxide product from baghouse dust. The El Indio process has the advantage of full-scale operating experience while WAROX Process has been tested only under pilot plant conditions. The applicability of the El Indio Process has not been tested on Giant's baghouse dust, while the WAROX process was developed on the basis of Giant's material. The fundamental difference in the flow sheets for the two processes is the manner in which fine dust in the fume reactor off-gas train is captured. The WAROX Process employs novel hot metal filtration technology and the El Indio Process uses a hot electrostatic precipitator (ESP) for equivalent purposes. The characteristics of the crude baghouse dust at Giant, expected to be significantly different in composition and more importantly in particle size distribution than the product generated at El Indio, could favour one dust collection technology over another, from technical and/or economic perspectives.

The relative efficiencies of a metal filter baghouse versus an ESP in capturing the very fine non-volatile (under fume reactor conditions) component of Giant's baghouse dust determine the quality of the final arsenic product. Any portion that is not captured reports to the cold baghouse and becomes incorporated as impurities in the final arsenic trioxide product. Meeting antimony targets in the final product is expected to present technical challenges to any processing technology, given that antimony oxides are associated with the very fine fractions of Giants crude baghouse dust. Based on pilot plant data, the hot metal filter technology employed by the WAROX Process achieved the processing target (0.2%) set for antimony during pilot plant trials. Equivalent information is not available for ESPs although existing Cottrells at Giant, which represent out-dated ESP technology, do not consistently achieve this target under current roaster operations.

The processing technologies under evaluation provide a means for reducing environmental liabilities associated with arsenic-rich dust inventories at Giant and recovering the costs of implementation through recuperation of gold values and sale of refined arsenic trioxide. However, both processing options would produce solid and aqueous waste streams requiring treatment prior to storage or discharge and both would generate fugitive (in-plant) and stack (atmospheric) emissions. The percentage of the arsenic lost in stack emissions is estimated to be 0.002% of throughput, with a corresponding arsenic emission level of 0.097 mg As/m^3, based on a 10 short tons/hour treatment facility employing the WAROX Process (B. Cross, 1999). While this estimated emission level is low relative to existing Arsenic Release Standards in the USA and other jurisdictions (Environment Canada et al, 1997), cumulative arsenic losses would still be considerable over the operating life of

the facility. Stack losses could be reduced further by adding a wet electrostatic precipitator and/or activated carbon adsorption system to the flow sheet, following the wet scrubber.

Should this type of waste management option be favoured over others under consideration by DIAND for management of baghouse dust stored and produced at Giant, more detailed investigations would be required as follow-up to this study. These would determine the economic and technical feasibility of reclaiming and processing current and future baghouse production at Giant through the WAROX or El Indio Processes (or combination of the two).

The results of the current study, while very conceptual in nature, suggest that both processing technologies are technically feasible and applicable to Giant.

Presenter Bio:

Serena Domvile graduated from the University of British Colombia with an undergraduate degree and post-graduate studies in Biochemistry. She worked at the Con Mine while owned by COMINCO and later Nerco Con Mine, between 1984 and 1990 as Director of Environmental Services. During this time, she developed two processing technologies, since patented in her name. One of the technologies is a water treatment process for removing arsenic and cyanide and the second is a process for upgrading the arsenic trioxide content and recovering metal values from baghouse dust and roaster calcines, using an organic solvent as the lixivant. While at Con, she also developed new analytical methods to support the mine's industrial hygiene and arsenic monitoring programs in general and specifically those for the Arsenic Plant, and arsenic trioxide refining plant operating in the 1980s.

Serena worked for two large engineering consulting firms in Vancouver between 1990 and 1996, in both cases in charge of the firm's environmental practice. In 1996, she installed analytical facilities at Barricks El Indio Mine in Chile to support the mines arsenic monitoring programs. In 1997, she introduced further analytical protocols at El Indio, allowing for more complete speciation of arsenic in exposed media.

In 1997, Serena Domvile formed her own consulting practice in Vancouver, Canada. In 1998, she incorporated a company in Chile. Since July of 1998, she has been consulting to the copper giant, CODELCO-Chile, at one of their large copper smelter operations in Northern Chile. As part of this work, she conducted a very extensive study of sources and levels of arsenic exposure within the smelter and refinery operations as well as within neighbouring communities. Her responsibilities included the development and introduction of analytical protocols for determining arsenic levels and distinguishing arsenic species present in potable and industrial water, gaseous and particulate air emissions, urine and hair. She has also evaluated the impacts of different operating and processing practices, efficiencies of existing engineering controls and the level of protection achieved by different respiratory equipment in capturing arsenic present in gaseous and particulate emissions at different smelting, converting and refining stages of the operation.

Option # 5: Hot Water Leach
Presenter: Patricio A. Riveros, Ph. D

Presentation Abstract:

As part of an initiative funded by Royal Oak and DIAND, pure As_2O_3 was produced from the Giant Mine Arsenic dust. Several aspects of the process were investigated, including:

1. Solubility tests of four dust samples from near 0^{o}C to 200^{o}C;
2. Ion exchange tests to remove antimony from the leach solutions;
3. Mineralogical characterization of the dust samples and leach residues using x-ray diffraction, scanning electron microscopy-energy dispersive x-ray analysis (SEM-EDX) and quantitative electron microprobe analysis; and
4. Dust vaporization tests in the range of 250-550^{o}C in an inert gas atmosphere and comparative tests in reducing neutral and oxidizing atmospheres.

On the basis of the results obtained, a laboratory procedure was devised and tested, that consisted of pressure leaching the arsenic dust for 2 hours at 150^{o}C, cooling to . 100^{o}C with pressure release, filtration at 95^{o}C, and precipitation of pure As_2O_3 by cooling to room temperature. The results indicate that leaching at 125-150^{o}C greatly improves the dissolution of As_2O_3 from the arsenic dusts. The leaching of As attained 93-99% of the total present, depending on the dust sample and the conditions used. Gold did not dissolve, but concentrated in the residues in amounts ranging from 30 to 55 ppm. The arsenic trioxide product, prepared under the preferred conditions, contained 95-99% As_2O_3, 0.06% Sb and 0.003% Fe. Based on the initial findings, options to recover a marketable As_2O_3 product and/or to oxidize and stabilize the dissolved arsenic are presented.

Presenter Bio:

Dr. Riveros has more than 20 years of experience in hydrometallurgy, especially solvent extraction, ion exchange and pollution abatement. Holding degrees in chemistry (B.Sc.) chemical engineering (M.Sc.) and metallurgical engineering (Ph.D.), Dr. Riveros has authored several technical publications and reports.

Option # 6: EMR Technologies
Presenter: Dr. J.M. Tranquilla

Presentation Abstract:

Arsenic Trioxide (As_2O_3) is a natural byproduct of conventional roasting of arsenical gold ores. Although there has been some historical secondary market for upgrading As_2O_3, it is generally recognized that modern practice requires some form of neutralization to prevent migration into the environment principally through water solution. Such neutralization strategies could apply equally well to existing As_2O_3 caches as well as ongoing production.

Laboratory scale operations have investigated several alternatives for the treatment and neutralization of As_2O_3 using microwave energy; these include vitrification, reduction to metallic arsenic and various chemical pretreatment alternatives which would incorporate As_2O_3 - laden baghouse dust into a standard mill cyanide treatment circuit without the production of As_2O_3. Of these options, the vitrification process appears to be the simplest, most robust and economically attractive.

Presenter Bio:

James Tranquilla received the BScE (1971) and MscE (1973) in electrical engineering from the University of New Brunswick and the PhD degree in electrical engineering from the University of Toronto in 1979.

From 1979 to 1996 he was a Professor in the Electrical Engineering Department at the University of New Brunswick and head of the radiating Systems Research Laboratory where his research interests included electromagnetic propagation, antennas, space based navigation systems, numerical modelling and microwave power applications.

In 1987, Dr. Tranquilla founded EM Technologies Inc., a private company, to develop industrial microwave applications. This company became a public company, EMR Microwave Technology Corporation, in 1994 where he is President and CEO.

EMR has developed several applications of its microwave technology in the mining and petroleum industries and is presently commercializing several of its processes in the pretreatment of precious metal bearing ores.

Option # 7: Bio Leaching
Presenter: Simon Purkiss

Presentation Abstract:

Bio leaching is a technology in which leaching is conducted with moderate thermophiles. This presentation will discuss:

- The process requirements and flow sheet
- How this process could be implemented in Yellowknife
- The direct and side benefits
- Safety and health issues
- Operations
- Cost estimates
- Environmental Impacts

Presenter Bio:

Simon Purkiss graduated from Birmingham University in Minerals Engineering in 1980 and joined Impala Platinum in South Africa in their graduate training scheme. He worked his way up to Concentrator Manager in 1990 and then left Impala in 1993 to complete an MBA in Cape Town. In 1994 he joined Gencor in the Minerals Technology department working on the marketing of the Gencor BIOX gold biological leaching process and the development of the nickel biological leaching process BioNIC. During this period he completed the first technology for equity deal in the Maggie Hays Australian nickel project. He was part of the Gencor/Billiton team examining the strategic approach of the Gencor/Billiton group to the nickel industry during 1994 and 1995. He left South Africa in 1996 to head up a joint venture project with Norilsk Nickel retreating some stored pyrrhotite dams. Due to the downturn in the metals industry and the Russian market he moved in late 1998 to start up a new technology company focussing on bacterial base metal leaching. Pacific Ore Technologies currently has associated laboratories in Canada and Australia and a number of base metal projects under development including a large scale biological heap leaching operation on a low grade nickel ore project in Western Australia.

Giant Mine Arsenic Trioxide Technical Workshop
Preliminary Evaluation Criteria and Matrix

Minimum Performance Criteria	**Pass / Fail**	**Comparative Criteria**	**Option #1: Pump &treat**	**Option #2: Solidification**	**Option #3: Autoclave**	**Option #4: WAROX**	**Option #5: Hot Water Leach**	**Option #6: EMR**	**Option #7: Bioleach**
Process Understanding: $ Is the process a proven technology? *(Does the process provide a permanent solution to arsenic management?* *(Can implementation of the process be completed within 50 years?* *(Can the process be operated in the Yellowknife environmental conditions?*	*Pass* *Pass* *Pass* *Pass*	**Risk -** Weight $Has this process been used at a commercial scale for As_2O_3 before? $Has it been used in similar environmental conditions? $What level of confidence is there based on the data/information regarding design? $What is the level of safety for workers during normal and upset conditions?							
Public Health and Safety: $ The routine operation of the process poses no known risk to public health. $ Has the end product been proven to be stable?	*Pass* *Pass*	**Service:** Weight $What reagents are required, what is the source of these reagents? $Design flexibility: does it fit in current mill process and equipment already available? $What is the level of flexibility of the process to changes in feedstock quantity and quality? $Can this process replace the roaster? $What is the level of recovery of arsenic and gold? $How expediently would this process eliminate the As_2O_3 over the next 20 years?							
		Impact: Weight $Is the displacement/disruption of natural features minimal ? $Are the land/space requirements minimal? $Is the volume of the stored end product material minimal? $What number of jobs would be created by this option? (Annually; in total)							
		Cost: Weight What are: $Capital costs? $O & M costs? $Closure costs? $Is there revenue recovery?							