DILLON
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Arsenic Trioxide Management - Royal Oak's Giant Mine

Technical Meeting

October 28, 29 and 30, 1997

INFORMATION PACKAGE

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Royal Oak Mines Inc.

DILLON CONSULTING

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

October 7, 1997

To: **Distribution List**

Your file Votre référence

Re: **Requested Attendance for a Technical Meeting on the Management of Giant Mine's Arsenic Trioxide**

Our file Notre référence

The Water Resources Division (WRD) of the Department of Indian Affairs and Northern Development (DIAND) in conjunction with the federal government, territorial government, the City of Yellowknife and Royal Oak Mines is holding a Technical Meeting of experts to review and discuss the technical aspects of management options for the arsenic trioxide stored underground at the Giant Mine site in Yellowknife, NT. The objective of this meeting is to determine, through the presentation of technical management alternatives and related discussion, viable options for the ultimate management of arsenic trioxide.

The Technical Meeting will be held on October 28, 29, and 30, 1997 in the conference facilities at Royal Oak's Giant Mine. Your attendance at this meeting is requested but should you be unavailable, I would appreciate that a representative from your department attend. This person should be familiar with the issues and be involved in the water licensing assessment and renewal process.

The focus of the technical meeting will be to, first, develop a common understanding of the history of the mine, the gold processing, the by-product (arsenic trioxide) and what are its effects. This will be accomplished, in part, with an on-site tour of Giant's mine process and arsenic storage facilities. Secondly, technical experts in the fields associated with various aspects of arsenic trioxide will provide an information base from which discussions and management options can be determined. Discussions will be formulated from smaller meeting groups that will generate opinions to be tabled with the entire technical group.

Dillon Consulting Limited has been retained to facilitate and organize this technical meeting. Should you have any questions, please contact either Gary Strong or Craig Thomas by phone (403)920-4555, fax (403)873-3328, or e-mail at yknwt@dillon.ca. Neill Thompson representing WRD-DIAND, can be contacted at (403)669-2659.

Please return a completed attendance form (attached) by October 10, 1997. A technical meeting agenda and a copy of Dillon's "Arsenic Trioxide Management Feasibility Study" are enclosed for your review.

Thank you for your consideration of this important request and we look forward to your participation.

Yours Sincerely,

David Milburn
Manager, DIAND-WRD
Attachment

Canada

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

DISTRIBUTION AND ATTENDEES LIST
October 28, 29 and 30, 1997

Royal Oak Mines Inc.,		**NWT Division:**	John Stard, Mine Manager
			Stephen Schultz, Environmental Manager
			Kent Morton, Mill Superintendent
		Project Dev Group:	David Donison, Mine Engineer
		Corporate Office:	Rick Allan, Manager, Mining Projects
		Technical Expert:	Sue Lendrum, Project Geologist
			Serena Domvile, Environmental Consultant
Environment Canada:,		**Yellowknife:**	Ed Collins, Chief, Environmental Engineering
			Steve Harbicht, Chief, Assessment/Monitoring
GNWT:	**RWED-**	**EPS:**	Lisa Dyer, Environmental Impact Analyst
		MO&G:	__________
	MACA:		Denis Adams, Director Community Operations
	H&SS:		Frank Hamilton, Environmental Health Consultant
			Dr. Sylvain Chouinard, Specialist Internal Medicine
	WCB-	**Mines:**	Sylvester Wong, Chief Inspector of Mines
			Peter Bengts, Inspector Mines and Mining Eng.
Yellowknife Health and Social Services:			Brad Colpitts, Sr. Environmental Health Officer
City of Yellowknife:			Adrian Bader, Manager Public Works
DIAND:	**WRD-**		David Livingstone, Director Renewable Resources and Environment
			David Milburn, Manager WRB-DIAND
			Jim McCaul, Head, Regulatory Approvals
			Neill Thompson, Pollution Control Specialist
			Shannon Pagotto, Environmental Specialist
	Minerals-		Dave Nutter, Director Mineral Resources
	E&C-		Rob Walker, Environmental Specialist
DFO:			Maria Healy, Habitat Specialist
Highwood Resources:		**Technical Expert:**	Terry Pepper, Metallurgist
Westmar Consulting:		**Technical Expert:**	Tony Willacy, Materials Handling Specialist
University of B.C.:		**Technical Expert:**	Dr. Bill Cullen Environmental Effects
University of Alabama:		**Technical Expert:**	Dr. Martin G. Bakker, Professor of Chemistry
Weber State University:		**Technical Expert:**	Dr. Jack Adams, Bioremediation
EMR Microwave Technology Corp.			Dr. J.M.Tranquilla, Microwave Technology
Hatch Consulting:		**Technical Expert:**	Holger Krutzelmann, Mineral Processing
MOEE:		**Ontario:**	John Barr, Environmental Regulations and Policy
Atomic Energy Control Limited:			Dr. Gary Thorne, Whiteshell Laboratories
NHRI:			Dr. John Gibson
Miramar Con Mine:			Cary Johnson, Mill Shift Supervisor
			Mike Borden, Senior Engineer
El Indio Mine, La Serena, Chile			Luis Wilson, Plant Manager

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 1:

08:00 **Registration**

08:20 **Introduction**
Dave Clark, Dillon Consulting Limited
David Milburn, Director, WRD-DIAND

08:45 **Giant Mine History and Current Practices**
Rick Allan (Project Manager), John Stard (Mine Manager), Kent Morton (Mine Operations) Royal Oak Mines

09:30 **What is Arsenic Trioxide and What are its Effects?**
Serena Domvile, forms and chemistry of arsenic, environment and health;
Dr. Bill Cullen, arsenic and the environment
Dr. Sylvain Chouinard, health effects of arsenic

10:45 **Coffee Break**

11:00 **Mine Facility Brief and Tours**
Rick Allan, Royal Oak Mines; 3 tour groups to be formed of 8-10 people.
1. Surface tour - general plant and mine facilities.
2. Mill tour - process tour from crushing to roaster to baghouse.
3. Underground tour - storage facilities.

12:00 approx. **Lunch** - To be served between tours

13:00 **Mine Facility Tours Continued**
Giant Mine Staff

15:30 **Meeting Venue Shift to Royal Oak Guest Lodge**
Light snacks and refreshments provided

16:30 **The Economics of Arsenic Trioxide.**
Sue Lendrum, Royal Oak

17:45 **Day 1 Summary and Closure**
Dave Clark, Dillon Consulting Limited

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 2:

08:15 **Opening Comments, Day 2 Agenda and Introductions**
Dave Clark, Dillon Consulting Limited

08:30 **Regulatory Overview**
Dave Clark, Dillon Consulting Limited; Water Licence
Laurie Bruce, Dillon Consulting Limited; CEAA

09:15 **Underground Storage of Arsenic Trioxide**
Rick Allan, Royal Oak; Overview, history and storage rationale.

10:15 **Coffee Break**

10:00 **Transport and Handling of Arsenic Trioxide.**
Dave Donison, Royal Oak; Underground removal methods.
Tony Willacy, Westmar Consulting; Surface handling.

12:00 **Lunch-** Tranquilla Treatment - EMR Microwave Technology

13:00 **Material Processing/Upgrading as an Economic Commodity**
Terry Pepper, Highwood Resources
Kent Morton, Giant WAROX, Royal Oak

14:30 **Material Processing/Stabilization/Neutralization as an Uneconomic Waste**
Dr. Martin G. Bakker, University of Alabama, Zeolite-Hydraulic Cement

Coffee Break
Dr. Jack Adams, Centre for Bioremediation, Weber State University

16:00 **Case Studies**
John Barr, MOEE regulatory experience
Holger Krutzelmann, Hatch Consulting
Luis Wilson, El Indio
Cary Johnson, Miramar Con Mine
Dr. Gary Thorne, AECL

17:30 **Day 2 Summary**
Dave Clark, Dillon Consulting Limited

18:30 **Informal Discussion and Social**
Explorer Hotel Hospitality Suite Sponsored by Dillon Consulting

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
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Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 3:

08:30	**Opening Comments and Day 2 Review** Dave Clark, Dillon Consulting Limited
08:45	**Working Group Sessions** Group facilitators from Dillon Consulting 3 to 4 working group discussions to identify the issues and concerns i.e., underground storage, environmental impact, process, economics and viable management options.
10:15	**Coffee Break**
10:30	**Meeting Group Session** Facilitators reports and total meeting group discussions to determine main management options and issues.
12:00	**Lunch**
13:00	**Working Group Sessions** Group facilitators from Dillon Consulting 3 to 4 working group discussions based on task assigned issues from morning sessions and development of recommendations based on assigned management options or issues.
14:45	**Meeting Group Session** Facilitators reports and total meeting group discussions to determine main management options and issues.
15:15	**Coffee Break**
15:30	**Technical Meeting Conclusions/Recommendations** Dave Clark, Dillon Consulting Limited; Open Session Discussions
16:45	**Closing Comments** David Livingstone, DIAND

Presenters and Topics

Presenter: Richard Allan, Manager - Mining Projects
Royal Oak Mines Ltd.

Personal Information:

Richard Allan graduated with a B.Sc. Mining Engineering from Queen's University, in 1978. He joined Royal Oak in 1991 as Chief Engineer at Giant and progressed to Technical Services Manager for the NWT, then transferred to Corporate Office in 1995 to head a team responsible for development of new mining projects. His background includes mine operations experience at Eldorado Nuclear, Canada Tungsten, and Barrick Gold (Holt-McDermott Mine).

Presentation: Oct. 28, 08:45 and Oct. 29, 09:15

A review of the history of Giant Mine and underground storage of arsenic trioxide will be presented. This will include the rationale behind the decision to place the material underground. The individual storage chambers will be identified, along with the inventory of stored material and its composition.

An overview of conditions in the area of the chambers will be given to establish some of the extraction parameters.

Royal Oak's short and long term strategy for storage and final disposition of the material will be described.

Presenter: Serena Domvile
SJ Domvile & Associates

Personal Information:

Serena Domvile is a consulting scientist (SJ Domvile & Associates) specializing in the monitoring, minimization and management of arsenical waste streams produced at mining operations through hydrometallurgical and pyrometallurgical processes. In support of programs for monitoring worker and environmental risks, she has installed systems to speciate arsenic present in biological, process and environmental media at mine sites in Canada, USA and South America. She holds numerous patents in the reprocessing and treatment of arsenical mine wastes.

Presentation: Oct. 28, 09:30

Her discussion presents an overview of the human and environmental risks associated with arsenic and the status of technology to address them. She will describe the typical sources and routes of arsenic exposure to worker and affected community populations and the role of engineering controls and hygiene practices in minimizing the potential for exposure. The behaviour and toxicological effects of different arsenical species will be compared and methods for monitoring these species outlined. Her discussion will cover the behaviour of arsenic in disposal and receiving environments and the options for minimizing its mobility and/or bioavailabiltiy to receptors.

Presenter: Dr. W.R. Cullen, Department of Chemistry, University of British Columbia

Personal Information:

Dr. Bill Cullen was born in Dunedin, New Zealand. He attended Otago Boys' High School and the University of Otago (B.Sc., M.Sc. with Dr. G.A. Bottomley) before moving to Cambridge University (Ph.D. with Professor H.J. Eméleus). He was appointed to the faculty of the Chemistry Department at the University of British Columbia, Vancouver, in 1958, where he has remained, apart from time spent visiting universities in Europe and Australia. He is a member of the American Chemical Society, a Fellow of the Chemical Institute of Canada and a Fellow of the Royal Society of Canada. His current research interests involve many aspects of the biogeochemistry of arsenic and antimony, the microbial degradation of PAH's and other organic contaminants, and the development of analytical methodology for the identification of metabolites. He is chair of the Environmental Chemistry Group at UBC and associate editor of *Applied Organometallic Chemistry.*

Presentation: Oct. 28, 10:00

<u>Arsenic in the Environment</u>

1. Abundance and Occurrence
2. Affinity of Arsenic for Sulfur
3. Biological Methylation of Arsenic
4. Toxicological Properties
5. Arsenic Species in the Terrestrial Environment
6. Arsenic Species in the Marine Environment
7. Biological Demethylation

Presenter: Dr. Sylvain Chouinard, M.D. Stanton Regional Hospital

Personal Information:

Dr. Chouinard is a specialist in internal medicine with over 10 years experience working in the Yellowknife region. He has had toxicological training in environmental contaminants and has had a great interest in environmental factors and their health effects for the last 30 years. He is the Chairman of the Environmental Committee of the NWT Medical Association.

Presentation: Oct. 28, 10:20

Dr. Chouinard will be speaking on acute and chronic effects of arsenic exposure.

Presenter: Sue Lendrum
Royal Oak Mines Inc.

Personal Information:

Sue Lendrum graduated from Queen's University in 1983 (Applied B.Sc. in Geological Engineering) and from McGill University in 1993 (Applied M.Sc. in Mineral Exploration). since 1989 she has worked with royal Oak Mines Inc. in both production and exploration.

Presentation: Oct. 28, 16:30

A review of historic, current and projected market conditions (supply, demand, sources, uses, prices) for arsenic trioxide and the wood preservatives, and their implications with respect to the possible extraction and upgrading of the Giant Mine's baghouse dusts.

Presenter: Dave Clark
Dillon Consulting Ltd.

Personal Information:

Dave Clark is a Partner of Dillon and is manager of our Vancouver regional office. He holds a Master's degree in Environmental engineering and has over 20 years of experience in the assessment of environmental impacts and environmental audits. Dave has been Project Manager on a number of large, multi-disciplined environmental assessment projects that have required approval under federal and provincial environmental guidelines and legislation. He has a sound working knowledge of federal, provincial, territorial and municipal environmental legislation in the Northwest Territories, Western Canada and Ontario.

Presentation: Oct. 29, 08:30

Dave Clark will be speaking about regulatory issues pertaining to the water licence renewal at Royal Oak's Giant Mine.

Presenter: Laurie Bruce
Dillon Consulting Ltd.

Personal information:

Laurie Bruce has worked in the environmental field for over fourteen years. Her experience as an environmental planner includes the project management and co-ordination of numerous multi-disciplinary environmental assessments under the Environmental assessment and Review Process

(E.A.R.P.), the Canadian Environmental assessment Act (CEAA) and the Ontario Environmental Assessment Act (EAA). These environmental assessments have been for waste management projects, harbor remediation programs, bridges, municipal infrastructure, Defense Canada initiatives, dredging activities, water control structures and marina developments.

Presentation: Oct. 29, 08:55

Laurie Bruce will be discussing the Canadian Environmental Assessment Act, specifically:

1. The purpose of the act,
2. The applicability of the act,
3. Types of studies,
4. Requirements of Studies,
5. Process,
6. Implications for the management of Giant Mine's arsenic trioxide.

Presenter: A. (Tony) Willacy, P.Eng.
Westmar Consultants Inc.

Personal Information:

Mr. Willacy has over 30 years extensive and diverse experience in project management, engineering and plant management in the consulting engineering, oil sand, primary aluminum and steel industries. In March 1996 he joined Westmar Consultants Inc., a firm specializing in the planning and design of bulk materials handling systems and civil and structural dsign engineering. He has worked on projects involving the handling of materials such as alumina oxide, oil sands, limestone, ores, sand and clay overburden, lead and zinc concentrates and coal.

Presentation: Oct. 29, 10:00

This presentation will provide an understanding for the materials handling characteristics of the material. Concepts for handling the material on surface will be described, in specific relation to the Giant property. Optional storage techniques will be described, along with progress to date in developing these options as viable alternatives.

Presenter: Dave Donison
Graham Mining Ltd.

Personal Information:

Dave Donison is a 1985 mining engineering graduate from Laurentian University in Sudbury, Ontario. He has had a range of production and engineering assignments both in Canada and abroad working for various mining companies and mining contractors/consulting engineers. Until recently, he was employed with Royal Oak Mines Ltd. in various capacities including General Manager at the Hope Brook Mine in Newfoundland and as Senior Engineer with the Projects

Development Group. He is presently employed as Projects Manager overseeing various mine development projects in Eastern Canada with the mine contracting, project management and engineering firm, Graham Mining Ltd.

Presentation: Oct. 29, 11:00

Arsenic trioxide dust is a byproduct of milling activities at the Giant Mine in Yellowknife. It has been stored underground at Giant since the mid-1950's. The dust has been stored in either specially excavated chambers or in completed/abandoned stops.

The dust ranges in characteristics from dry, dusty material (similar to processed flour) to damp, slightly compacted material, depending on the length of time it has been in storage as well as the local environment.

Presently, consideration is being given to removing or "mining " the dust from the underground storage chambers to surface for reprocessing. Various methods are being examined and these methods are summarized in this paper/presentation. Included are a brief description of the evaluations required to advance these methods from the conceptual to operating stage.

Presenter: Dr. J.M. Tranquilla
EMR Microwave Technology Corporation
Fredericton, New Brunswick

Personal Information:

James Tranquilla received the B.Sc.E (1971) and M.Sc.E. (1973) degrees in electrical engineering from the University of New Brunswick and the Ph.D. 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 modeling 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 1995, 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.

Presentation: Oct. 29, 12:00 noon

Dr. Tranquilla will be discussing how microwave technology can be used to treat arsenic containing mine waste.

Presenter: Terry Pepper
Highwood Resources

Personal Information:

Mr. Pepper is a metallurgist with almost 30 years experience in research, development, production, technical support and remediation. He has a Professional Degree from the Colorado School of Mines and a Master's Degree from the University of Utah. He has worked fro Kennecott Copper Corporation, the Colorado School of Mines Research Institute, Texasgulf Inc., Unocal/Molycorp and is currently Vice-President of Technical Development for Highwood Resources Ltd. He has developed patented precesses for the recovery of copper, lead, zinc and silver from pyrite concentrates.

Presentation: Oct. 29, 13:00

Once the arsenic concentrate is recovered from the underground storage, the material may be treated to stabilize the arsenic for disposal or purified to allow sale to customers in the US. stabilization generally occurs one of three ways: limiting water penetration (cements polymers), limiting arsenic solubility (precipitation with iron in autoclave) and absorption of dissolved arsenic (zeolite and flyash). Purification involves using the differential chemical, thermal and physical properties of arsenic and it's contaminants to achieve a separation of the materials. Current Royal Oak test work is focusing on hydrometallurgical purification of the arsenic through either hot water or ammonium hydroxide leaching of the arsenic concentrate. The benefits of purification and sale is that the material is gone, it is put to a use and gold entrained in the arsenic concentrate is potentially recoverable.

Presenter: Kent Morton, Mill Superintendent
Royal Oak Mines Inc.
Yellowknife, NT

Personal Information:

Kent Morton has been involved in mill operations in base metals, potash and gold for nearly thirty years. He has been at the Giant mine for a little over a year as mill superintendent. Previous to this posting he was site manager at Golden Bear mine, a gold roasting and heap leach operation in Northern B.C.

He has worked at Giant on two previous occasions, seven years as mill superintendent and five years working as project superintendent and sat on the Technical Advisory committee to the NWT Water Board during these periods. He has been involved with various arsenic studies over the years and was instrumental in developing the WAROX purification process in the late 1980's.

Presentation: Oct. 29, 13:45

Kent will be giving a brief overview of the milling process at Giant, and later on will discuss WAROX project.

Presenter: Dr. Martin Bakker, Associate Professor in Physical Chemistry
University of Alabama, Dept. Of Chemistry
Tuscaloosa, AL

Personal Information:

Dr. Bakker graduated with a B.Sc. in Chemistry (1st Class honours) in 1980 and a Ph.D. in Physical Chemistry in 1985 from Canterbury University, New Zealand. From 1986 to 1988 he was a Postdoctoral Fellow at the Australian Institute of Nuclear Science and Engineering, Sydney, Australia and The University of Western Australia, Perth, Australia (1986-1988), and as a member of the Radiation and Photochemistry Group, Chemistry Division, Argonne National Laboratory (1988-1990). He is currently an Associate and Assistant Professor in the Department of Chemistry at the University of Alabama.

Dr. Bakker's research experience has centered on the use of Spectroscopic Techniques, particularly Electron Paramagnetic Resonance (EPR), to study molecular structure and motion. EPR, NMR and other techniques have been applied to study:

1. The interaction of surfactants on particle surfaces,
2. Formation of radical cations in zeolite matrices,
3. Mechanism of action of a zeolite/cement medium for the stabilization of wastes containing arsenic and other inorganic pollutants,
4. Sheer flocculation of fine particles in the mining industry,
5. Charge transfer in conducting polymers,
6. Formation and reactions of sugar radicals.

Presentation: Oct. 29, 14:30

<u>Zeolite-Hydraulic Cement Composite for Arsenic Stabilization</u>

Between 1993 and 1995 the U.S. Bureau of Mines carried out a study of various methods for stabilizing arsenic containing mine waste. This work led to the development of a cement/zeolite containment media capable of stabilizing arsenic at levels well above that obtainable with cement only. Samples of arsenic containing waste from a copper smelter and from arsenic acid production were stabilized using the medium and successfully passed the TCLP leaching tests.

In the containment media the arsenic was believed to be present predominantly as arsenate ions. Work carried out at the University of Alabama focused on understanding why the zeolites, which contain sites where cations are bound to the zeolite, should act to contain the negative arsenate anions. Investigations have confirmed that the zeolite is neither decomposed, nor sealed in the basic cement medium, so that migration between the zeolite and the cement portions of the matrix appears possible.

Prior to the closure of the Bureau of Mines the U.S. patent had been applied for. This patent has been allowed, and the rights are held by the inventors of the process, as the U.S. government has no interest in developing the process further.

Presenter: Dr. Jack Adams
The Center for Bioremediation
Ogden, Utah

Personal Information:

Dr. Adams is currently the Director of the Center for Bioremediation at Weber State University, Ogden, UT. The Center was established to facilitate development, enhancement, and marketing of bioremediation and environmental restoration technologies based on microorganisms, biological materials, and enzyme components. The Center's focus is on metals, other inorganics, and metal-organic mixed contaminants. His education and research background is in molecular and applied environmental microbiology. He received my Ph.D. from Utah State University, Logan, UT in molecular environmental microbiology. Before his current position, he worked for the federal government in environmental biotechnology for 18+ years as an employee and consultant. Research and projects centered on factors affecting microbial environmental stability, modification of microbial attributes, and microbial function in the environment. In his two most recent positions prior to the Center for Bioremediation, the U.S. Bureau of Mines and U.S. Army, he was responsible for developing and evaluating technologies at bench-, pilot-, and field-scale. At the Bureau he headed the Biotechnology Program which developed and implemented technologies for metal and other inorganic remediation.

Presentation: Oct. 29, 15:15

<u>Biotechnologies for Arsenic Removal</u>

Background
The Center for Bioremediation specializes in innovative technologies for removal, stabilization, and/or recovery of metals from solids and solutions to create resources out of waste materials. Arsenic is present at nearly all smelter sites and fly ash is often considered a toxic substance because of its heavy metal content. Fly ash residues from ore roasting and incineration of solid municipal waste might be referred to as a secondary ore because they can contain several metals in sufficient amounts to allow economical recovery. Currently, most fly ash is either immobilized with cement and deposited in controlled landfills, or stored in underground repositories. However, newer technologies are developed that incorporate fly ash into cement products, pipes, and building materials, such as bricks. Biotechnology offers additional alternatives.

Technology
Integration of microbial technologies, developed for remediation of metal-contamination using naturally-occurring microorganisms, can also produce recoverable/recyclable metals. The arsenic process has several components that can be applied as needed: in situ metal sulfide stabilization in solids, controlled leaching of metals from solids, metal precipitation from solutions, and metal ion removal from solutions.

Metal Stabilization. Arsenic stabilization in solids is achieved through treatment of the solids with waste organics and bacteria (e.g., *Desulfovibrio sp., Pseudomonas sp.* etc.) that convert the metals present to insoluble metal sulfides. This stabilization process is enhanced by the addition of waste organics and lowering the oxygen content of the solid materials.

Bioleaching. Removal of metals from contaminated solids (e.g., ores, soil, fly ash, etc.) is accomplished through natural microbial processes that convert organic and/or inorganic wastes into metal-leaching solutions. Microorganisms (e.g., *Thiobacillus sp*., *A. niger* etc.) produce metal-leaching sulfuric, nitric, and organic acids using economical substrates from the food processing and agricultural industries. Microbes used in bioleaching produce various surfactant and emulsifier metabolic by-products which can enhance leaching efficiency.

Metal Removal/Recovery. Metal-laden solutions such as bioleaching, process, and waste solutions are treated in tank and pond bioreactors using naturally-occurring microorganisms (e.g., *Desulfovibrio sp.*, *Pseudomonas sp.*, and wastewater microbial consortia) to bind, reduce, and/or precipitate metals. These microbial bioreactors produce significantly less sludge than lime and ferric arsenic precipitation, and solution pH adjustment is not required as it is for H_2S gas and other chemical treatments.

Polishing. Biosorbents, derived from microorganisms and waste materials act much the same as ion exchange resins and can remove even trace concentrations of metal anions and cations from water.

Technology Status

This integrated process can treat a broad range of metal-contaminated solids and solutions with pH ranges from 1 to 9. Bioleached solids pass U.S. Environmental Protection Agency's Toxicity Characteristic Leaching Procedure (TCLP) test and met National Pollutant Discharge Elimination System criteria regarding metals. In demonstration tests, **metal stabilization** halted the mobility of anions – As, Cr, and Se, and cations – Al, Ca, Cu, Cd, Cr, Hg, Mg, Pb, Zn, and U. **Bioleaching** accelerated similar anion and cation removal from soils, ores, and sediments using a recirculated leach solution. **Metal removal/recovery** from solutions has been field tested at pilot-scale. **Solution polishing,** using waste organics and microorganisms, has been tested on various mining solutions. The integrated process described is ready for laboratory-scale treatability studies, optimization, and scale-up to meet specific waste treatment demands.

The Center for Bioremediation and collaborating companies provide an interdisciplinary team of scientists and engineers experienced in laboratory- to field-scale process development. The Center for Bioremediation, a not-for-profit research center, conducts contracts in bioprocess development, bioremediation, and environmental restoration for government and industry.

Presenter: John Barr
Ministry of the Environment and Energy (MOEE)
Kenora, Ontario

Presentation: Oct. 29, 16:00

Mr. Barr will be discussing regulatory issues, specifically experience that MOEE in Ontario has had dealing with arsenic containing mine wastes.

Presenter: Holger Krutzelmann
Hatch Consulting

Personal Information:

Mr. Krutzelmann has a B.Sc. Mining Engineering (Mineral Processing) from Queen's University, 1978. He has 22 years of operating and metallurgical experience in the mining industry in base metal, potash and gold operations in Canada, Greece, Indonesia and the USA. His positions have ranged from operator to superintendent and he was Chief Metallurgist in two plants utilizing pressure oxidation.

Presentation: Oct. 29, 16:30

Mr. Krutzelmann will be reviewing operating gold plants that process arsenopyrite for gold recovery. A listing of these plants and relative operating and capital costs will be provided along with a description of the arsenic residue management involved.

Various processing options will be presented including roasting, pressure oxidation and others. He will also be discussing operating problems regarding arsenic residue.

Presenter: Luis J. Wilson
Barrick Gold Corporation
La Serena, Chile

Personal Information:

Mr. Luis J. Wilson was born in Chile where he obtaine the Civil Metallurgist Engineer Degree (1969) at the University of Santiago, Chile. He WORKED IN Chile in the mineral processing at Chuquicamata copper mine and as a metallurgical consultant for small mines process improvement. In Canada, Luis worked at Dow Chemical, Sarnia, Ontario and at Rabbit Lake Operations, Camenco Corporation. Presently, he is working as Plant Manager at El Indio Plant, Chile (Barrick Gold Corporation).

Presentation: Oct. 29, 17:00

Luis Wilson will discuss the current operating conditions of the El Indio mine. The El Indio plant process includes a concentrator and roasting processes to treat a complex copper-gold-arsenic ore.

Presenter: ***Cary Johnson, Mill Shift Supervisor***
Miramar Con Mine
Yellowknife, NT

Presentation: Oct. 29, 17:30

Cary Johnson will discuss the current autoclave operations at the Miramar Con Mine in Yellowknife, NT.

Presenter: ***Dr. Gary Thorne***
Atomic Energy of Canada Limited
Pinawa, Canada

Presentation: Oct. 29, 17:50

Dr. Thorne will discuss current AECL practices and research related to hazardous materials.

Technical Meeting Facilitators:

Dave Clark, P.Eng., Lead Facilitator
Managing Partner Dillon Consulting Limited, Vancouver, B.C.

Dave Clark is a Partner of Dillon and is manager of our Vancouver regional office. He holds a Master's degree in Environmental engineering and has over 20 years of experience in the assessment of environmental impacts and environmental audits. Dave has been Project Manager on a number of large, multi-disciplined environmental assessment projects that have required approval under federal and provincial environmental guidelines and legislation. He has a sound working knowledge of federal, provincial, territorial and municipal environmental legislation in the Northwest Territories, Western Canada and Ontario.

Before joining Dillon in 1987, Dave held the position of Director of Land Protection with Saskatchewan Environment. He was directly responsible for the development and implementation of the spill/emergency response program and participated as a response member of the Provincial Spill Team having received extensive training in the areas of: risk assessment (acute and chronic affects), materials containment and monitoring and site remediation. Dave served five years as the Saskatchewan member on the Canadian Council of Ministers of the Environment (CCME) Waste Management Steering Committee.

Laurie Bruce, B.E.S., M.A.

Laurie Bruce has worked in the environmental field for over fourteen years. Her experience as an environmental planner includes the project management and co-ordination of numerous multi-disciplinary environmental assessments under the Environmental assessment and Review Process (E.A.R.P.), the Canadian Environmental assessment Act (CEAA) and the Ontario Environmental Assessment Act (EAA). These environmental assessments have been for waste management projects, harbor remediation programs, bridges, municipal infrastructure, Defense Canada initiatives, dredging activities, water control structures and marina developments.

Prior to joining Dillon, Laurie worked for Environment Canada. While at Environment Canada, Laurie was a member of the Secretariat of the Regional Screening Co-ordinating committee where she was responsible for reviewing projects subject to EAR. Specifically, she was responsible for ascertaining if federal assessment requirements had been adequately addressed.

Gary Strong, P.Eng.
Managing Partner Dillon Consulting Limited, Yellowknife, NT.

Gary Strong is the Managing Partner of Dillon's Yellowknife office. Gary is a municipal engineer with over 12 years experience in the planning, conceptual design, detailed design, and construction of municipal and industrial infrastructure projects. During his 7 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. Design of infrastructure in the northern climates must account for both the technical challenges and also be sensitive to the environmental and local concerns. An integral part of many of the projects undertaken in the

NWT is the requirement for regulatory and community approvals. As a project manager, Gary has been involved with the approval process on a number of occasions and has developed a keen understanding of the current regulatory framework that governs projects in the NWT.

Craig J. Thomas
Head, Natural Sciences and Environmental Planning
Dillon Consulting Limited, Yellowknife, NT.

Craig Thomas has over twelve years experience in the environmental consulting field with three years prior work experience with the Ontario Ministry of Natural Resources, Fisheries Management Division. Craig has a solid background of knowledge and experience in the disciplines of environmental planning and biology where a good portion of his project involvement has included the application of environmental management practices as they relate to many environmental issues including fisheries, wildlife, and wetlands. Craig currently co-ordinates the natural sciences and environmental planning group of Dillon's Yellowknife Office in the Northwest Territories. He recently co-authored Dillon's report on the feasibility of managing arsenic trioxide.

Paul Green, B.Sc.(Eng)
Environmental Engineer
Dillon Consulting Limited, Yellowknife, NT.

Paul Green is an environmental engineer with Dillon's Yellowknife office.

During his time with Dillon, Paul has been a key researcher, gathering and interpreting data for a variety of projects. Paul is co-author of the Arsenic Trioxide Management Feasibility Study and organized the search for and compiled the data relating to the marketing and disposal options for arsenic trioxide.

Notes: Laurie Bruce (Dillon) 29/10/97.

CEAA
Basic Screening
Documentation : Env. effects - inc. malfunction
cumulative

Significance
Public concern

Comprehensive Studies - full class doc.

Rick Allan → As_2O_3/Au reserve
Thermistor data

Dave Donison
75 t/day mining rate
Vacuuming - remote
Clam mucking - remote
draw point mucking
Slurry pumping

Tony Willacy
Bags - 3 types (TRP Bldg. time = 1 year)
Compaction, Bladon 105 lb/ft^3

WAROX

300 hours pilot plant.

99.5 % As_2O_3

EMR. microwave – Tranquilla

Zeolites – Balder

Stabilisation of As. (USBM) → closed in 1994.

Zeolites bind cation.

10% [illegible] why would As anion be bound. ?

As 10% of wt. of "cement / zeolite / waste" product

Bioremediation – Jack Adams, Weber

.2 oz/ton.

Notes:

Work group #2 - Session #1

underground — leave + monitor
pump or flood ?
treat in situ (stabilize)
consolidate in one location
preferential pathways
In situ storage areas + freeze.
Overburden in pits (tailings)

Transport and Handling to surface
→ Safety for workers.
Removal — vacuuming, clams etc. (no one technology)
→ Surface storage (dep. on processing)
→ will not be able to remove all ?
→

(Facilitating mode:
use a simple framework for discussion)

Stabilization

Bulk material (260,000 t)

Autoclave (ratio 1.1:1 Fe/As)
acid generation H_2SO_4
Sulphur / Iron, O_2 (not air)
Con.

Calcium arsenate – isolate from CO_2

Ferric arsenate – w/out autoclave

micro wave tech – arsenic sulphide (no O_2)

Notes:

Issues / Criteria (for evaluation of mgt. options)

Human Health risk (zero exposure?) workers communities

Ecological risk

Public perception / Consultation / education

(time scale ~~change~~ → 5 yrs / 20 + yrs.)

Approvability (legislation, Can/Int.)

Technical feasibility

Economics

Liability - residual

Inherent risk

Expertise

Confidence in technology, science, markets proven? (stable?)

"monitor - ability"

Contingency measures

Flexibility for future change

Exporting our problem?

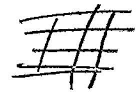
Ease of Implementation

Removal and Handling / surface storage

Premise: a reason to bring to surface.

Vacuuming

pumping as slurry ? ?



digging

Sublimation

Solidification in situ before removal

Electrostatic ?

Vacuuming

Notes:

refined criteria

1. Human Health
2. Env. risk
3. Public perception / education
4. Regulatory – approvability / accept....
   - national / International
   - current / future
   - requirements
5. Technical Feasibility
   - simplicity
   - ability to in place
   - short term
   - State of development
   - Available contingency
   - future R&D req'd
   - unknown ?
6. Liability – Company
   - Crown
   - 3rd parties
   - Future / long term
7. Economics / cost

Notes:

Notes:

Arsenic Trioxide Management Feasibility Study

Draft Report

August 22, 1997

DRAFT

Arsenic Trioxide Management Feasibility Study
Yellowknife, NT

Indian and Northern Affairs Canada

95-2832-04-01

Submitted by

Dillon Consulting Limited

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Dillon Consulting was contracted by Indian and Northern Affairs Canada (DIAND) to assess and prepare a report on the current market, technology and feasibility for managing arsenic trioxide currently stored underground at the Giant Mine. The report was not intended to be a detailed assessment but was to provide indications of current technologies, first order estimates and initial economic requirements for Departmental planning purposes.

Information was obtained from several sources. The Internet provided most of the initial information pertaining to companies handling arsenic trioxide in some capacity and directed further inquiries. Information accuracy was confirmed by contacting named companies directly and by cross checking with government databases. The U.S. Geological Survey Web site contained a large quantity of current information regarding the economics, usage and the outlook for arsenic as a saleable commodity. The Economics of Arsenic, 1990 edition, published by Roskill Information Services in the UK was another useful source of data for all aspects of arsenic trioxide usage. Information on the technical aspects of arsenic trioxide processing and handling was extracted from case studies and scientific reports authored by a number of different groups.

The prospect of selling arsenic trioxide on the open market looks hopeful. Arsenic trioxide has been used for many purposes in the past including: agricultural chemicals (pesticides and herbicides), wood preservatives, glass manufacturing and alloying metals. Environmental concerns have reduced the use of arsenic trioxide in all sectors with the exception of wood preservatives. Three wood preservative companies: Hickson Corp., Osmose Corp. and CSI in the U.S. would have the capability to accept large, continuous shipments of arsenic trioxide from Giant. All three expressed some interest in the product during telephone conversations. Hickson Corp. received approximately 20 000 tons of crude arsenic trioxide in the 1980's from Giant and has been waiting for results of Giant's research into upgrading the crude material. Osmose Corp. received arsenic trioxide from the Con Mine treatment plant until about 1990. CSI has not had dealings with mines in the NWT but expressed interest. All three companies would require the crude product in the vaults be upgraded to a minimum of 95% arsenic trioxide and a number of other impurities would have to be reduced before they would accept the product. The electronics market for pure arsenic metal is growing, but uses small volumes of product and requires very high purity material, 99.9999%, making it an unlikely target market for Giant's product.

The arsenic trioxide would have to be upgraded to a minimum of 95% before being widely marketable. Purities of 99% or higher would command a better price. Two purification methods are currently in common use, sublimation and solvent extraction. Sublimation involves heating the arsenic trioxide containing material to a sufficient temperature to convert the trioxide to a gaseous state. The gas is then passed through a series of condensers to produce

a purified product. An alternate method uses hot water to dissolve the arsenic trioxide, leaving behind impurities. The trioxide is then recrystallized as a product with at least 99% purity. Con Mine in Yellowknife constructed a processing plant to purify arsenic trioxide from a tailings pond sludge using the hot water leach method. The plant ran through the 1980's and successfully treated Con's stockpiled arsenic trioxide to produce 99.7% pure arsenic trioxide that was sold to Osmose Corp. in the U.S.. The gold and silver present in the treatment residue were successfully reclaimed, contributing to the economic success of the plant.

Approximately 100,000 ounces of gold are believed to be present in the baghouse dust kept in the arsenic trioxide storage vaults at Giant Mine. Several metallurgical processes have been developed to recover precious metal values from mine wastes containing high levels of arsenic. Con Mine successfully developed a method to extract gold and silver from the residue produced in the arsenic trioxide treatment plant. Rough calculations suggest that removing the arsenic trioxide would leave a gold concentration in the dust greater than that currently being mined by Giant. Economic factors suggest that any attempt to purify the arsenic trioxide for sale should probably include recovery of the gold contained in the dust.

Accessing and conveying the material to the surface for processing would require careful design to minimize health and environmental hazards. The primary concern would be the generation. Inhalation of the arsenic or absorption through the skin can be fatal. The problem would not be difficult from a technological standpoint as Giant has considerable experience dealing with arsenic trioxide and has completed studies on the problem. A quantity of material was successfully accessed in the 1980's to be sent to the U.S. for sale and testing.

A number of technologies and methods are available to treat the material on-site to render it environmentally inert. The most environmentally stable form of arsenic is as a ferric arsenate. Arsenic naturally occurs in this form. The cost of converting arsenic trioxide into ferric arsenates can be high as a molar ratio of 3-4:1 iron to arsenic is required. The conversion is carried out in an autoclave as the process requires temperature of 130-140°C and pressures of 100 psi. Iron arsenate sulphate hydroxy compounds are another stable arsenic form produced in an autoclave form but again require a large amount of iron and some sulphur. Arsenic sulphates can be produced in a roaster and are considered stable enough for long term disposal. A pilot scale process has been developed to produce arsenic sulphide in a bioreactor with an efficiency rate six times that of chemical means. Conversion of the waste to calcium arsenate is no longer considered a suitable disposal method as the calcium reacts with CO_2 in the atmosphere to form calcium carbonate, thereby releasing the arsenic into the environment. The most economically viable method for on-site disposal may be to combine the arsenic trioxide with a chemical cement to produce a hardenable product. In some instances the cement may be reusable for structural purposes, eg. road beds. The substances produced from any these processes could be disposed of safely in tailings ponds.

Off-site treatment or disposal options appear to be quite costly, with initial estimates in excess of 750 $/ton. The amount of material to be disposed of and the resultant cost make this option unlikely.

The problem of handling large amounts of arsenic trioxide appeared in most literature regarding precious metal mines. Several case studies were obtained discussing options for disposing of arsenic trioxide and have been included in Appendix H of this report. The most pertinent study was carried out by Nerco Con Mine and outlines the methods used to dispose of a large amount of arsenic trioxide in an economically and environmentally acceptable manner. Giant has also studied the options for marketing the arsenic trioxide and has produced a number of reports detailing the technological requirements to handle and process the waste material. Copies of these reports were not obtained but would provide specific information on the Giant Mine case.

1.0 INTRODUCTION

Giant Mine in Yellowknife, NT processes refractory ores using roaster technology. Over 40 years of mine operation, a significant amount of material has accumulated as a by-product of the roasting process. Between 80 and 95% of this material is arsenic trioxide. Arsenic trioxide is a highly toxic material which must be carefully managed. Dillon Consulting was contracted by DIAND to assess and prepare a report on the current market, technology and feasibility for managing the arsenic trioxide currently stored in underground vaults on the mine site.

The report is not intended to be a detailed assessment but is to provide indications of current technologies, first order estimates and initial economic requirements for Departmental planning purposes.

1.1 Objective

Assess and prepare a report on the current market, technology and feasibility for managing arsenic trioxide currently stored underground at the Giant Mine.

1.2 Scope of Work

Specific areas of interest to be examined by the contractor includes but is not limited to:

1) current market and conditions for the product in its' raw state and as an upgraded/refined material. This includes a list of the known producers, similar sources and industrial users. Any future known trends should be identified if they may affect the market (ie: changes in its use in the wood preservative industry). This should include an economic review including the material value versus the cost of getting it to market.

2) technology, requirements and feasibility to upgrade the product to the market standards.

3) current technology, markets and feasibility of processing the material to recover additional products. (ie: gold)

4) technology, requirements and feasibility of accessing and conveying the material to surface or otherwise gaining access to it for management purposes.

5) current technologies and feasibility available to process the material on-site to render it environmentally inert and unavailable (ie: solidification, encapsulation, autoclave, etc.). This should include utilizing the Con autoclave or other similar technology.

6) current companies, approved facilities and locations that can accept the material for on or off-site management/treatment/ disposal.

7) current technology and feasibility of long term surface storage.

8) any other management options which may be available or emerging

9) provide information on relevant projects, pilot projects, parallel or applicable projects & technologies, case studies, experts, references or standards/legislation the contractor may obtain during their work.

The above assessments should address any residual waste byproducts resulting from on-site processing.

This is not a detailed assessment. It is intended to provide indications of current technologies, first order estimates and initial economic requirements for Departmental planning purposes.

1.3 Background

Arsenic is a naturally occurring substance that is found most often in compounds with sulphur, either alone or in combination with various metals. It is a recovered as a by-product of processing certain ores where the primary product is copper, lead, zinc, gold and/or silver. Royal Oak's Giant Mine; a gold producing mine located in Yellowknife, NT produces arsenic mainly as arsenic trioxide through the roasting of arsenic gold ores.

Since 1980, a treatment plant has produced raw arsenic trioxide as a by-product from the gold roaster unit. (Before then the arsenic residues were stored underground). Before 1979 and 1980, research and development was carried out on producing a marketable grade of trioxide, and pilot plant was built. In 1980, Giant Yellowknife signed a contract with a US customer to sell their raw trioxide production, and storage silo and truck load out facility was constructed. (Roskill, 1990)

In 1987, shipments and sales of arsenic trioxide stopped and a research programme was initiated to upgrade the arsenic trioxide in order to produce a more saleable product. A decision was expected by the end of 1989 concerning production from a gold/arsenic project in Yellowknife, North West Territories and a start up date tentatively set for January 1991. (Roskill, 1990). The project would use crude arsenic, which is stored in the permafrost, as its raw material to produce arsenic trioxide and gold.

Currently, Giant Mine has accumulated approximately 250,000 tons of baghouse dust which is stored underground.

2.0 METHODOLOGY

An extensive search of available sources was carried out to determine options available for the disposal of large amounts of crude arsenic trioxide mine waste as specified in the Scope of Work. An Internet search was conducted by searching for "arsenic trioxide" using all of the available search engines. A number of subsequent searches were carried out using key words to narrow down the returned information fields. Information gained from sites located through these searches served as the basis for further searches of libraries both on and off the "net", and provided the contact numbers for several companies and agencies that dealt with arsenic trioxide in some capacity. Companies and government agencies were contacted directly and information relating to arsenic trioxide was gathered over the phone or by fax. The individuals contacted often provided information on additional sources that were then utilized.

2.1 Sources

A number of different sources were used during the information search including the Internet, government personnel, industry and an assortment of libraries. The major sources of information used were:

- The "Internet". Searches were carried out using available search engines for "arsenic trioxide" and variations such as "arsenic trioxide - remediation".
- Chemical and wood preservative manufacturers
- Roskill Information Services, The Economics of Arsenic, 1990
- U.S. Geological Survey - Minerals Information Sheets, 1995-1996
- U.S. Geological Survey - Mineral Commodity Summary, February 1997
- Canadian Minerals Yearbook, 1991
- Mines and Minerals Activities, 1993
- Natural Resources Canada Minerals and Metals Sector, On-line Information
- Statistics Canada, On-line Trade Query
- Canadian Institute of Treated Wood
- The Legislative Assembly Branch Library, Yellowknife, NT

- The NRC Library, Vancouver, BC
- The Natural Resources Library, Ottawa, ON
- Natural Resources Canada - CANMET
- DIAND Environmental Library
- Canada-NWT Business Centre
- Environment Canada
- Department of Resources, Wildlife and Economic Development
- Canadian Intellectual Property Office
- Environmental disposal companies
- Waste remediation companies
- Workers Compensation Board
- Department of Safety and Public Services
- Industry Canada
- U.S. Department of Commerce, National Technical Information Service

3.0 DATA COMPILATION

3.1 Economics

It was determined that arsenic trioxide is used in a number of different products including wood preservatives, glass manufacturing, agricultural chemicals and nonferrous alloys. Of these, the wood preservative industry accounts for 90% of the of all arsenic products consumed in the U.S. (U.S.G.S., Mineral Commodities Summaries, Pg. 1). The wood preservative industry has shown steady growth in its' use of arsenic trioxide whereas the other end uses have shown a steady decline. (Roskill, Pg. ii). The market research therefore focused on the wood preservative industry and the inorganic chemicals supply industry as being the most likely market for the product. In order to assess the marketability of the arsenic trioxide in Giant's storage vaults, a number of wood preservative and chemical companies were contacted.

COMPANY	COMPANY TYPE	COMMENTS
BDH Chemicals Canada, Ltd.	Chemical	No longer distribute arsenic trioxide.
All Chemie, Ltd.	Chemical	Purchase ultra-high purity material.
Transene Co., Inc.	Chemical	Purchase high purity and small quantities.
Wego Chemical and Mineral Corp.	Chemical	Interested, but depends on purity.
Canaimex, Inc.	Import/Export	Importer/exporter.
Amalgamet Canada	Chemical	Distributor for French supplier.
Spectrum Bulk Chemicals	Chemical	Lab grade, 99% or higher.
Great Western Inorganics, Inc.	Chemical	Manufacturer of arsenic trioxide.
Hickson, Inc.	Chemical/Wood Preservative	Major wood preservative manufacturer.
Chemical Specialties, Inc.	Chemical/Wood Preservative	Major wood preservative manufacturer.
Osmose, Inc.	Chemical/Wood Preservative	Major wood preservative manufacturer.
Diachem Industries, Inc.	Wood Preserving	No longer use arsenic.
Napier International Tech., Inc.	Wood Preserving	No longer use arsenic.
Pierce and Stevens Canada, Inc.	Wood Preserving	No longer use arsenic.
Chem-Craft	Wood Preserving	Do not use arsenic.
Solignum, Inc.	Wood Preserving	No longer use arsenic.
Korzite Coatings	Wood Preserving	Do not use arsenic.

All Chemie, Ltd.
Fort Lee, NJ
Products: As - metal, As_2S_5, As_2O_5, As_2O_3, As_2S_3.

Distributor of ultra-high purity material, 99.99% or higher. (Pers. Com., August 08, 1997)

Transene Co., Ltd.
Rowley, Ma
Products: As_2O_5, As_2O_3.

Purchaser of high purity material, greater than 99% and in small quantities for use in the electronics industry. (Pers. Com., August 08, 1997)

Wego Chemical and Mineral Corp.
Great Neck, NY
Products: inorganic chemicals.

Purchase product with a purity of 99% at a minimum. Product is obtained from China. (Pers. Com., August 01, 1997)

Cinemas, Inc.
Montreal, PQ

Import/export company that does not use the product themselves but would transport it to markets. (Pers. Com., August 07, 1997)

Amalgamate Canada
Toronto, ON

Distributor for an arsenic trioxide producer in France. Distribute arsenic trioxide in purities of 98.5% or greater. (Pers. Com., August 05, 1997)

Spectrum Bulk Chemicals
New Brunswick, NJ
Products: As - metal, As_2O_5, As_2O_3.

Distributor of lab grade quality material, and in relatively small quantities. (Pers. Com., August 01, 1997)

Great Western Inorganics, Inc.
Arvada, CO
Products: arsenic acid, arsenic disulfide, As_2S_5, As_2O_5, $AsBr_3$, $AsCl_3$, AsI_3, As_2O_3, As_2S_3, arsenic triselenide.

Manufacturer of arsenic trioxide but not a user. (Pers. Com., August 14, 1997)

Hickson, Inc.
Conley, GA
Products: wood preservative, including CCA.

Manufacturer of arsenical wood preservatives. Accepted delivery of approximately 20 000 tons of arsenic trioxide from Giant in the 1980's. Operate the largest arsenic acid plant in the world. Feedstock specifications are: 95% arsenic trioxide, <400 ppm iron, <1000 ppm lead and <100 ppm chloride. (Pers. Com. August 07, 1997)

Chemical Specialties, Inc.
Harrisburg, NC
Products: wood preservatives, including CCA.

Manufacturer of a line of products for use in the wood preservative industry, primarily CCA. Purchase in excess of 10 MM lbs. of arsenic trioxide from several countries around the world in bulk bags of 1.0 or 1.7 metric tons. Process arsenic trioxide into arsenic acid at their Harrisburg, NC facility. Plant feedstock requirements are: 95-99% arsenic trioxide, 500-5000 ppm iron, 0.5-1.0% antimony, <300 ppm mercury, <100 ppm chloride, <0.5% water. (Pers. Com. August 12, 1997)

Osmose Inc.
Memphis, TN
Products: wood preservatives, including CCA.

Purchased arsenic trioxide from Con mine until approximately 1990. Manufacture arsenical wood preservatives, specifically CCA. Feedstock requirements are: 99% arsenic trioxide, <0.02% iron, <0.02% lead and <0.01% chloride. (Pers. Com. August 14, 1997)

In addition to contacting companies that handled arsenic trioxide, several reference sources were consulted to try and determine the current market conditions for the product, producers, similar sources, industrial users and trends in the market.

Roskill Information Services, The Economics of Arsenic, 1990

- Arsenic trioxide accounts for 97% of world arsenic production. World production was estimated at 54 800 tons in 1987, up from 40 000 tons per year in the late 1970's but less than peak levels of 70 000 tons per year in the late 1960's. (Pg. i)

- The arsenic industry has increasingly been affected by environmental factors, particularly in the USA and Western Europe where the actions of environmental organizations have curtailed some operations. (Pg. ii)

- The potential supply of arsenic is much greater than demand. (Pg. 1)

- A treatment plant at Giant Mines in the N.W.T. has produced raw arsenic trioxide as a by-product from the gold roaster unit. During 1979 to 1980, research was carried out on producing a marketable grade of trioxide and a pilot plant was built. In 1980, Giant signed a contract with a US customer to sell their raw trioxide production, and construction work was started on a storage silo and truck load out facility. The construction work was completed in early 1981, and 1 093 tonnes of raw arsenic trioxide were shipped to the US customer during the year. In 1987, shipments and sales of arsenic trioxide stopped and a research programme was initiated to upgrade the arsenic trioxide in order to produce a more saleable product. A decision was expected by the end of 1989 concerning production from a gold/arsenite project in Yellowknife, NWT, and a start up date tentatively set for January 1991. The plant would produce approximately 8 000 tonnes/year of arsenic trioxide and 2 000 ounces/year of gold. The project will only proceed if a market can be secured for at least half of the planned arsenic production. (Pp. 20-21)

- The sales of arsenic trioxide from 1981 to 1987 were: (Pg. 21, Table 14)

Year	Volume (tons)
1981	1,093
1982	1,361
1983	726
1984	1,119
1985	2,055
1986	368
1987	---

- Campbell Red Lake Mines in Ontario has a production capacity of 1 360 tons of arsenic trioxide per annum. In both 1985 and 1986, they produced approximately 1 270 tons of arsenic. The principal use of the arsenic is in wood preservatives. All arsenic is exported, mainly to the USA. (Pp. 21 - 22)

- Cominco opened a new US$13 million arsenic recovery plant at the Con mine in the N.W.T. in late 1983. Feed for the plant came from a 65 000 ton stockpile accumulated over the 25 years prior to 1970. Building of the plant had been prompted by a directive from the NWT Water Board to Cominco to find the best way of disposing of the stockpile, which was determined to be a potential environmental hazard. Stabilization and permanent impoundment of the sludge had been rejected as unacceptable to future generations, and wasteful of the contained gold, silver and arsenic values. The 5,000 tpd capacity plant was scheduled to process 32 tpd of sludge in order to produce 15 tpd of arsenic trioxide with a purity of 99.5% arsenic trioxide together with gold and silver. Most of the trioxide output is shipped to North America for wood preservative and agricultural chemical end uses. (Pg. 22)

- Cominco Ltd. operated an integrated smelter and refining complex at Trail, BC. An arsenic pentoxide solution was produced here as a by-product of other metallurgical operations until January 1989 when Cominco's Electronic Materials Division was bought by the Johnson Matthey Corporation. Arsenic trioxide is no longer produced. (Pg. 22)

- Equity Silver Mines Ltd. in British Columbia produced calcium arsenate which was disposed of in the U.S. Currently they are mining a grade of ore with a very low arsenic content and are not producing arsenic products. (Pg. 23)

- Table 46: Markets for CCA treated lumber market sector. (Pg. 75, See also table 1 in Appendix B)

- Table 49: Comparison of wood treatment costs. (Pp. 81-82, See also table 2 in App. B)

- Table 61: Imports of arsenic trioxide and pentoxide and acids by major trading countries, 1984 -1987. (Pg. 107, See also table 3 in App. B)

- Table 79: Europe and the USA: Arsenic trioxide prices, 1976 to 1989. (Pg. 128, See also table 4 in App. B)

- Environmental pressure groups and organizations have fought for thorough investigations of the toxicities of arsenic compounds and, where applicable, have paved the way for appropriate legislation to minimize the exposure of individuals to toxic arsenic compounds. (Pg. 137)

- In June 1984 the US Environmental Protection Agency issued a rule restricting the use of three major types of wood preservatives: creosote, inorganic arsenicals and pentachlorophenol. This measure:

a) prohibited consumer sales of wood treatment products containing these chemicals: manufacturers would be required to label their products for trade use only, (although consumer sales are a very small part of the total market).

b) required new protective measures for staff in wood treatment plants. In 1986, OSHA announced an industry assistance programme to help plants monitor arsenic levels as required by law. If the arsenic level is higher than 10 micrograms per cubic meter of air, operators will be required to wear respirators.

c) proposed a new consumer awareness programme for consumers of treated timbers (with the long-term sanction that if the industry cannot organize it, the EPA may require the labelling of all such timber). This aspect of the rule was upheld by a Federal judge in mid-1985.

d) required a reduction in the hexachlorobenzene and hexachlorinated dibenzodioxin contamination found in pentachlorophenol.

e) prohibited the use indoors, with some exceptions, of wood products treated with pentachlorophenol or creosote, unless the wood is subsequently sealed with varnish or shellac. (Pp. 140-141)

- The EPA decided that all three of these wood preservatives exceeded the agency's risk criteria for cancer-causing potential, but it was decided not to seek a ban because of the great benefits wood preservatives give to society. If an alternative preservative without the same risks could be developed, the risk/benefit balance may change and there may be cause to ban these preservatives. (Pg. 141)

- Work has been done to find alternatives to arsenic in current preservatives with less toxic elements such as zinc, fluorine, chlorine and boron. (Pg. 142)

<u>U.S. Geological Survey - Minerals Inormation, 1996</u>

- The U.S. was the world's largest consumer of arsenic in 1996, accounting for about two-thirds of world demand. (Pg. 1)

- On a contained metal basis, arsenic trioxide accounted for 99% of imports in 1996. (Pg. 1)

- China is the world's largest producer of both arsenic trioxide and arsenic metal. (Pg. 1)

- China accounts for 44% and 84% respectively of trioxide and metal imports into the U.S. (Pg. 1)

- Overall consumption of arsenic remained relatively unchanged in 1997, for the third straight year. (Pg. 1)

- Wood preservatives accounted for 90% of total arsenic demand. (Pg. 1)

- Arsenic trioxide was consumed in the production of arsenic acid for formulation of CCA by the three principal producers of arsenical wood preservatives in the U.S.: Hickson Corp., Conley, GA; CSI, Harrisburg, NC and Osmose Corp., Memphis, TN. (Pg. 1)

- Arsenic consumed in agricultural uses continued to decline following the EPA's 1993 cancellation of arsenic acid for use as a cotton desiccant. (Pg. 1)

- The average customs value for imported arsenic trioxide in 1996 was 22 cents per pound, down by about 2 cents per pound from that of 1995. (Pg. 2)

- Prices for high-grade (minimum 99%) arsenic trioxide generally are quoted at an 8 to 12 cent per pound premium to low-grade (minimum 95%) arsenic trioxide. (Pg. 2)

- Commercial-grade arsenic trioxide is recovered from the smelting or roasting of nonferrous metal ores or concentrates in at least 18 countries. (Pg. 2)

- With the major market for arsenic being the production of arsenical wood preservatives, the demand for arsenic is closely tied to the home construction market, where wooden decks containing arsenical preservatives have become ubiquitous. (Pg. 2)

- In 1988 about 450 million cubic feet of wood were treated with waterborne preservatives (98% estimated to be CCA). In 1984, 300 million cubic feet were treated. In 1994, 500 million cubic feet were treated and in 1995 450 million cubic feet were treated. In 1995, waterborne preservatives were used for about 75% of all treated lumber. (Pg. 2)

- The prohibition on use of CCA preservatives in certain applications and the greater acceptance of alternative preservatives could negatively affect future demand. (Pg. 2)

- The apparent demand for arsenic trioxide in wood preservative declined slightly in 1996 despite an increase in housing starts. Restocking by wood preservative manufacturers and carry-over from the 13% housing growth in housing starts in 1994 may have served to boost the apparent demand in 1995. (Pg. 2)

- Future demand for arsenic is expected to closely follow that for new home construction, although the replacement and renovation markets could increase as a percentage of total market share. (Pg. 2)

- Although environmental pressures may continue to cause curtailment of existing capacity, given the abundance of high-arsenic residues from nonferrous metal processing, world supplies of arsenic trioxide are expected to remain adequate to meet projected need. (Pg. 2)

- Table 1: Arsenic Supply-Demand Relationships. (Pg. 3, See also table 5 in App. B)

- Table 2: U.S. Imports for Consumption of Arsenicals. (Pg. 3, See also table 6 in App. B)

- Table 4: Arsenic Trioxide: World Production, By Country. (Pg. 4, See also table 7 in App. B)

U.S. Geological Survey - Minerals Information, 1994

- In 1994 local and state concern over the toxicity of chromated copper arsenate (CCA) wood preservatives led to State restriction on their use in certain applications. Responding to the concern that CCA could leach from timbers and accumulate in invertebrate marine life, New Jersey became the first State to restrict their use in certain marine applications. Effective July 19 1994, restrictions on the use of CCA pressure-treated wood were imposed along four rivers that are rich in shellfish. Accordingly, CCA treated wood will be prohibited in the construction of new or rebuilt marine structures at marinas containing slips for five or more boats. However, in recognition of a lack of alternative materials, pilings were exempt from the ban. Alternative materials for planking include plastic lumbers and South American hardwood. (Pg. 1)

- Mexican trioxide has the advantage of bulk shipping via rail cars allowing consumers to avoid having to handle and dispose of contaminated drums. (Pg. 1)

U.S. Geological Survey, Mineral Commodity Summaries, February 1997

- All arsenic metal and compounds consumed in the United States were imported, principally from China. (Pg. 1)
- Three principal manufacturers of wood preservatives consumed most of the arsenic trioxide for the production of arsenic acid for formulation of CCA wood preservatives. (Pg. 1)
- About 90% of all arsenic was consumed in the production of wood preservatives. The balance was consumed in glass manufacturing, agricultural chemicals, nonferrous alloys and miscellaneous uses. (Pg. 1)
- The value of arsenic metal and compounds consumed was estimated at $20 million. (Pg. 1)
- Table 1: Salient Statistics - U.S. (Pg. 1, See also table 8 in App. B)
- A recently developed alternative, ammoniacal copper quaternary, which avoids using chrome and arsenic, has yet to gain widespread usage. Non-wood alternatives such as concrete, steel or plastic lumber may be substituted in some applications for treated wood. A South American hardwood, ipe, which requires no chemical treatment, has been used in some localities in ocean front boardwalks. (Pg. 2)

Canadian Minerals Yearbook, 1991

- Approximately 40 tonnes of stockpiled arsenic trioxide material from Giant was shipped to the U.S. for testing. (Pg. 9.1)
- Recovery technology includes the electrostatic precipitation of dust, cooling of the arsenic containing gases, and collection of arsenic trioxide in the baghouse which grades 85 to 93%. (Pg. 9.1)
- Since the Royal Oak takeover, Giant's White arsenic oxide (WAROX) plant project to treat crude arsenic (currently 85% pure) to produce high-quality industrial product (99% pure) has been placed on hold. This project would involve using sintered metal technology for recovering arsenic pentoxide to be used in the wood preservative industry. (Pg. 9.1)
- Arsenical wood preservatives are used wherever rot or insect damage may occur, such as in building foundations, fence posts, submerged footings and utility poles. (Pg. 9.3)

- Substitutes are increasingly being found for most of arsenic's major end uses, although arsenic may be the preferred material due to its lower cost and superior qualities. (Pg. 9.4)

- In September 1991, the Commission of the European Communities issued council directives relating to restriction on the marketing and use of arsenic and its' compounds. These include prohibition of arsenic compounds for the following: prevention of fouling by micro-organisms, plants or animals the hulls of boats; cages, floats, nets and any other appliances or equipment used for fish or shellfish farming; any totally or partly submerged appliances or equipment; and preservation of wood. The ban does not apply to solutions of inorganic salts of the CCA (copper chromium arsenic) type employed in industrial installations using vacuum or pressure to impregnate wood. (Pg. 9.5)

- The outlook for arsenic is somewhat uncertain, although supplies are abundant and demand is expected to remain relatively flat. (Pg. 9.6)

- Environmental concerns have reduced the demand for arsenic. (Pg. 9.6)

- Table 1: Canada, Arsenic Production and Trade, 1989-1991. (Pg. 9.7, See also table 9 in App. B)

Mines and Minerals Activities, 1993

- Table 12: Mineral Production , Northwest Territories, 1984-1993. (See also table 9 in App. B)

Natural Resources Canada Minerals and Metals Sector, Online Information

- Canada, Reported Consumption of Nonmetallic Minerals table:

  Canada consumed 125 tons of arsenic trioxide in 1991. Consumption data for 1992 to 1995 was confidential. (See table 11 in App. B)

Statistics Canada, Online Trade Query

- Table of Canadian Exports. (See table 12 in App. B)

- Table of Canadian Imports. (See table 13 in App. B)

3.2 Market Processing

Several methods exist for processing crude arsenic trioxide into higher grade material. General information on the sublimation process and the water extraction process was found in Roskill's The Economics of Arsenic. Information on other processing technologies was found in patent abstracts.

PATENT NUMBER	PROCESS TYPE	COMMENTS
Cdn. Patent No. 1314149	Evaporation into a gas stream.	See abstract in appendix D.
U.S. Patent No. 3923478	Scrubbing of flue gas with aqueous solvent.	Referenced in Cdn. Patent No. 1314149, deals with flue gas having a high sulphur dioxide component.
U.S. Patent No. 4588564	Removal of arsenic trioxide from scrubbing water.	Referenced in Cdn. Patent No. 1314194.
U.S. Patent No. 4605812	Catalyzed removal of arsenic from gases.	Referenced in Cdn. Patent No. 1314194.
U.S. Patent No. 4489046	Evaporation of arsenic trioxide in a furnace.	Referenced in Cdn. Patent No. 1314194, could also be used to recover gold values.
U.S. Patent No. 4244735	Caustic leach and crystallization.	Referenced in Cdn. Patent No. 1314194, could also be used to recover gold values and render arsenic inert.
Swiss Patent No. 273779	Evaporation and recrystallization of arsenic trioxide.	Referenced in Cdn. Patent No. 1314194.
German Reference No. 131840	Extraction using sulphuric acid.	Referenced in Cdn. Patent No. 1314194.
Con mine process	Multi stage hot water leach.	See Appendix I.
El-indio gold mine process	Precipitation from flue gas.	See Appendix I.
U.S. Bureau of Mines	Sulphuric acid leaching.	See Appendix I.

Roskill Information Services, The Economics of Arsenic, 1990

- The flue dusts from the roaster or smelter are collected by Cottrell Electrostatic precipitator; combined with galena or pyrite to prevent arsenite formation, and then roasted so that the arsenic trioxide is vaporized. The vapour passes through a series of condenser "kitchens", encountering progressively lower temperatures from 220°C to 100°C or less, and recondenses to 90 to 95% pure arsenic trioxide. This material can then be purified further by resublimation in a reverbatory furnace. From here the trioxide passes through another series of kitchens. In those with a temperature of

120°C to 189°C, arsenic trioxide of 99% to 99.9% purity condenses. The poorer grades from the other kitchens are either recycled or marketed as crude arsenic trioxide of a minimum 95% purity. (Pg. 14)

- Arsenic trioxide can be separated from impurities by dissolution in water. Arsenic trioxide is fairly soluble in water at temperatures approaching 100°C whereas its common impurities are not. The arsenic trioxide solutions are separated from the insoluble impurities and vacuum cooled to yield arsenic trioxide of at least 99% purity. (Pg. 14)

Canadian Patent No. 1314194
Patent Holder: Derka, Jaroslav R.

- The arsenic trioxide is evaporated into a non reactive carrier gas (eg. nitrogen) in a heated chamber, a fluidized bed or an electrical plasma reactor. The arsenic trioxide is precipitated from the gas into a fluidized bed of arsenic trioxide particles cooled by water evaporation. The final size of the arsenic trioxide particle can be controlled. The material from which the arsenic trioxide is removed can then be treated to remove valuable metal components (eg. gold). (Derka, Jaroslav R., Pp. 5-15)

- Arsenic trioxide has a higher solubility in ammonia than in hot water and an ammonia leach process can be used to purify arsenic trioxide. This process is not currently being used. (Derka, Jaroslav R., Pg. 2)

U.S. Patent No. 3923478

- The arsenic trioxide is scrubbed from the 350-400°C roast gas using a (preferably aqueous) solvent. The system is kept closed. The product is concentrated and crystallized out of the solution. Any unwanted deposits formed are removed by dissolution in unsaturated arsenic trioxide solution. By using systems in parallel and switching liquid flows, it is possible to run a continuous process with minimal solid or liquid effluent. (Derka, Jaroslav R., Pp. 2-3)

U.S. Patent No. 4588564

- Arsenic trioxide is recovered from flue gas scrubbing water. The crude arsenic trioxide crystals collected are purified by treatment with 50-150 g/l hydrochloric acid at a temperature of less than 30°C. (Derka, Jaroslav R., Pg. 3)

U.S. Patent No. 4605812

- Arsines are removed from a hydrocarbon or inert gas stream by contacting the stream with a copper (II) chromate catalyst. (Derka, Jaroslav R., Pg. 3)

U.S. Patent No. 4489046

- The arsenic containing waste is melted under oxidizing conditions in a furnace forming an oxide slag melt. Turbulence is caused in the melt while a reducing atmosphere is maintained to support the formation of arsenic trioxide which is then driven off and recovered by condensation. (Derka, Jaroslav R., Pp. 3-4)

U.S. Patent No. 4244735

- The arsenic is precipitated as an insoluble, non-polluting ferric-arsenic compound, carried through a chloride leach step to recover metals in the waste and then disposed of. Alternately, the arsenic can be recovered using a caustic leach and crystallization process. (Derka, Jaroslav R., Pg. 4)

Swiss Patent No. 273779

- A mechanical process operating at 500-600°C and 0.5-1.0 mm of H_2O vacuum is used to evaporate arsenic trioxide from the waste product. The arsenic trioxide vapours are recrystallized. (Derka, Jaroslav R., Pp. 4-5)

German Patent No. 131850

- Flue gases containing sulphur dioxide, arsenic trioxide, halides and dust are cleaned by washing with a circulating sulphuric acid solution. The solution is adjusted to a very low concentration of sulphuric acid to allow dissolution of the halides. The sulphuric acid solution is separated and subjected to a vacuum evaporation to vaporize the halides and crystallize the arsenic trioxide. (Derka, Jaroslav R., Pg. 5)

The Con Mine Separation Process

- A two stage counter current leach at an operating temperature of 95°C is used to extract arsenic trioxide from waste material. Hydrogen peroxide is added to enhance leach kinetics. The crystallization liquor is thickened and filtered using powdered activated carbon to remove crystallization modifiers and to enhance product purity. The hot pregnant liquor is passed through four stages of evaporative cooling and crystallization in growth type units. The crystallized product obtained is 99.8% pure arsenic trioxide. (Anthony, David H.; Pg. 140)

El-indio gold mine process

- Gases from the roaster are passed into an oxidation chamber with enough ambient air to allow complete conversion of all sulphates to oxides. The oxidation temperature is 750°C. The gas from this chamber is passed through a heat exchanger to cool it to 390±10°C. This cooled gas is passed through two electrostatic precipitator to remove all particulate matter. The gas exiting the precipitator at 300°C contains arsenic trioxide vapour and is rapidly cooled to 120°C in a hatch chamber. The arsenic trioxide precipitated out of the gas in this step is collected in a baghouse. The product collected has a purity of 97% to 97.5%. (Smith, E.H. and Parades, Eduardo, Pp. 154-157)

U.S. Bureau of Mines

- Sulphuric acid is used to dissolve arsenic and metals present in the smelter dust. The temperature is controlled between 24 and 90°C to determine the amount of a particular metal extracted. Solids are filtered out and the temperature is lowered to precipitate the metals. Sulphur dioxide is sparged into the solution to precipitate the arsenic trioxide. (Chementator, April 1990, Pg. 23)

3.3 Recovery Technology

The amount of gold present in the stockpiled flue gases has been estimated at over 100 000 ounces. The literature was reviewed and attempts were made to contact a company mentioned in the literature as developing new processes to recover precious metals from waste products in order to determine the feasibility of recovering gold from the waste material.

COMPANY	PROCESS	RESULTS/COMMENTS
Artech Recovery Systems, Inc.	Cashman process	International patent holders for Cashman process.
U.S. Patent No. 4615731	Hydromettalurgical recovery process	Referenced in Cdn. Patent No. 1314149, see App. E
U.S. Patent No. 4244735	Hydromettalurgical recovery process	Referenced in Cdn. Patent No. 1314149, see App. E

Artech Recovery Systems Inc.
Golden, CO

- A single step hydrochloric acid-oxygen leach is carried out as 120°C and 60 psi. Base and precious metals are dissolved as chlorides and later recovered by precipitation or solvent extraction and electrowinning. Arsenic is precipitated as ferric arsenate which can be disposed of more readily than arsenic trioxide. (Chementator, April 1990, Pp. 22-23)

- Attempts were made to contact Artech Recovery Systems Inc. but were unsuccessful.

U.S. Patent No. 4615731

- Precious metals are separated from an aqueous acid solution containing gold, one or more metals from the platinum group and one or more of the nuisance elements: bismuth, lead, tin, arsenic and antimony. The aqueous acid is treated with sulphur dioxide in the presence of selenium and a halide to reduce and selectively precipitate selenium and the precious metals which are then separated from the solution. (Derka, J.R., Pg. 3)

U.S. Patent No. 4244735

- Arsenic is precipitated as an insoluble ferric arsenate compound in the first processing step and carried through a chloride leach step, in which it is insoluble, to recover the metals. The metals in solution are separated from the ferric arsenate precipitate and recovered. The ferric arsenate precipitate is disposed of. (Derka, J.R., Pg. 3)

3.4 Materials Handling

Information on accessing and conveying the arsenic trioxide material to the surface was not readily available. The specifics of this type of operation are dealt with on a case by case basis. Some general information on the problem was obtained from telephone conversations with the Environmental Protection Division of Renewable Resources and the Worker's Compensation Board. Other information regarding personal protection requirements and Transportation of Dangerous Goods was obtained from Environment Canada.

Environmental Protection Division, Renewable Resources(Pers. Com., Aug. 13, 1997)
Yellowknife, NT

- The material is stored in stopes on the first and second levels of the mine.

- Removal should not prove problematic from a technological stand point as Giant has stored the material for years and has considerable experience handling it.

- The material is "augured" into the stopes so it should be possible to "auger" it out again the same way.

- If 90% of the material could be removed, the rest could be dissolved in water and pumped out.

- Occupational Health and Safety would have protocols regarding arsenic handling.

- TDG regulations would apply to the arsenic trioxide if it were shipped off site. Giant would have to be registered as a hazardous waste producer, the carrier would have to be registered as a hazardous materials carrier, the receiver would have to be registered as a hazardous materials user and a TDG manifest would be required.

Worker's Compensation Board(Pers. Com., Aug. 13, 1997)
Yellowknife, NT

- Dust generation would be the main concern for workers. Self-contained breathing apparatus and full protective chemical suits may have to be used when workers are in direct contact with the arsenic trioxide material.

- Health and environmental monitoring programs would have to be initiated.

Copies of the TDG and MSDS information obtained from Environment Canada have been included in Appendix F.

3.5 Waste Stabilization and Storage

Research literature indicates that arsenic trioxide is soluble in water at a level of 12.1 g/l at a temperature of 0°C (Stefanakis, M. and Kontopoulos, A., Table III, Pg. 294), which is significantly higher than the Canadian MRL of 0.05 mg/l. The solubility of arsenic trioxide increases with temperature and at extremes of pH. Arsenic trioxide is not suitable as a disposal option for arsenic if there is any possibility of water contacting the waste material. (Kyle, J. H. and Lunt, D., Pg 347). A number of companies were contacted and several studies were reviewed in order to determine options for the stabilization and storage of arsenic trioxide.

Company/Group/Patent	Process/Technology	Comments
Stark Encapsulation, Inc.	MetlCAP encapsulation process.	Can form reusable cement substance, see App. G.
U.S. Government	Zeolite-hydraulic cement containment medium.	See App. G.
Phytotec, Inc.	Phytotechnology.	Uses plants to take up arsenic from waste material, see App. G.
Center for Bioremediation	Utilize bioreactor technology to remediate arsenic containing waste material.	See App. G.
University of Alberta, environmental research group.	Assorted technologies.	They have not done specific arsenic work, but would be interested.
U.S. Patent No. 4244735	Precipitation as ferric-arsenic compound.	Referenced in Cdn. Patent No. 1314149, See App. D.

<u>Stark Encapsulation Inc.</u>
Cleveland, OH

- A proprietary process is used to bind the arsenic into a hardenable chemical cement matrix. This material can then be disposed of or reused as a cement (eg. in roadbeds). Treatment prices ranged from 20-80 U.S.$ per ton depending on the properties of the arsenic containing medium, the concentration of arsenic in the waste and the intended fate of the product. (Pers. Com., Aug. 5, 1997)

<u>U.S. Government</u>

- A process was developed to contain arsenic in a zeolite-hydraulic cement medium. Zeolite in amounts from 5-60 wt% is mixed with portland cement in amounts from 95-40 wt%. A chosen amount of small particle size hazardous material is added to this mixture and more portland cement is added. Water is added to produce a free flowing paste which is poured into molds and hardens. The addition of zeolite reduces the lower physical strength and hardening problems associated with using portland cement alone. (Brown, Patrick M. *et al*, Pp 5-7)

<u>Phytotec, Inc</u>
Monmouth Junction, NJ

- Plants are used to "phytoremediate" contaminated material. Contaminants are absorbed by the plants which are then stabilized and landfilled or processed to remove the metal.

A process is being developed to remediate arsenic, but will not be ready for at least another year. (Pers. Com., August 8, 1997)

Center for Bioremediation
Weber State University
Ogden, UT

- Biological processes are used to convert waste material into usable or disposable forms. Work has been done at the pilot plant scale to convert arsenic into arsenic sulphide which is considered stable enough to be stored in a landfill. Reported efficiencies were reported at six times those of chemical methods. A process is being developed to purify arsenic trioxide to a level high enough for it to be used by the wood preservatives industry. (Pers. Com. Aug. 8, 1997)

University of Alberta, Environmental Research Group
Edmonton, AB

- The possibility of freezing and storing arsenic containing mine waste in permafrost has been studied. Work has not been done with arsenic trioxide specifically, but interest was expressed in developing options for gold mine tailings treatment and disposal. (Pers. Com. Aug. 8)

U.S. Patent No. 4244735

- Arsenic is precipitated as an insoluble ferric-arsenic compound. The arsenic is rendered non-polluting by fixing it with ferric ions and can be disposed of. (Derka, Jaroslav R., Pg. 4)

Two studies on disposal options for arsenic trioxide were reviewed to collect background information on the solubility of various arsenic compounds. The Sefanakis study has been included in appendix G and the Lundt study has been included in appendix I.

Production of Environmentally Acceptable Arsenite-Arsenates From Solid Arsenic Trioxide
Stefanakis, M. and Kontopoulos, A.

- Arsenic trioxide produced by roasting can be effectively stabilized as ferric arsenate. Increased pH and temperature at precipitation adversely affects arsenic solubility. (Pg. 302)

- Mixed Fe(II)-Fe(III) arsenates were less suitable for arsenic removal than ferric-arsenates. (Pg. 301)

- A molar ration of 7:1 Ca:As was required to achieve a solubility in compliance with environmental standards. Calcination at 800°C rendered calcium arsenates acceptable at a molar ratio of 3:1 Ca:As. (Pg. 302)

<u>An Investigation of Disposal Options for Arsenic Trioxide Produced from Roasting Operations</u>
Kyle, J.H. and Lunt, D.

- Ferric arsenate precipitates produced a very low solubility product, but required large quantities of oxidant, lime and ferric sulphate to produce. (Pp. 352-353)

- Ferric arsenite precipitates showed low solubility but required large amounts of production chemicals. (Pg. 353)

- Calcium arsenate showed low solubility but long term thermodynamic stability has been proven to be deficient. (Pg. 353)

- Chemical solidification of arsenic trioxide or of calcium arsenate showed promise from an economic standpoint. (Pg. 353)

A representative from CANMET was contacted and options for stabilization and storage were discussed. (Pers. Com., Aug. 13)

- Calcium arsenate was once considered an option but long term testing has shown that calcium carbonate was formed upon exposure to air and the arsenic was released.

- Arsenic can be adsorbed onto ferric hydrate which passes leaching tests and is dischargeable. A molar iron to arsenic ratio of 3:1 is required. The product has a low density and a high volume. Theoretically the iron could react with carbon dioxide in the air to form iron carbonate, and release the bound arsenic. The process has been found to be more suitable for arsenic in solution.

- Arsenic can be converted to $FeAsO_4{\bullet}H_2O$ at 130-140°C and 100 psi in an autoclave. A dense thermodynamically stable product is formed. Product formed is the same as stable arsenic compounds found in nature.

- $FeAsO_4{\bullet}H_2O$ can be formed at atmospheric pressure using chloride media. The oxidation step is rate limiting and can be accelerated with hydrogen peroxide. Corrosion problems have hindered the development of this process.

- Very low solubility iron arsenate sulphite hydroxy compounds (Bukovskyite) can be formed in autoclaves. Iron demand is high.

- Lead iron arsenate hydroxide (pyromorphite) compounds show low solubility but the involvement of lead complicates the environmental aspects of material storage.

- Low solubility arsenic sulphide can be formed in a roaster and stored in tailings ponds. The process is used at a mine in Chile. Maintenance of the equipment can be problematic due to large amounts of arsenic contamination.

3.6 Materials Management

Three waste handling companies were identified in Alberta that could handle the disposal of arsenic trioxide waste. Telephone conversations were carried out with each company to determine the disposal services offered by each company as well as approximate prices for each option. Requested information was obtained from Custom Environmental Services.

COMPANY	SERVICES OFFERED	COMMENTS
Custom Environmental Services/ Proeco Corporation	Secure landfill, incineration, treatment	See Appendix H
Environmental Management	N/A	N/A
Phillip Environmental	N/A	N/A

Custom Environmental Services/Proeco Corp.
Edmonton, AB

- Secure landfill would be reliant upon the make-up and concentration of the waste material. The estimated disposal cost was $Cdn. 750 per ton.

- Incineration was estimated to cost $Cdn.1 300 per ton.

- Treatment would be an option depending on make-up and concentration of the waste material. Estimated costs were $Cdn.1 600 per ton.

- Final prices would be dependant upon the volume and location of the material. Transportation costs could be very high.

The Ontario Waste Exchange and the Canadian Chemical Exchange were both contacted but were unable to provide information on disposal options for the arsenic trioxide waste.

3.7 Other Studies

Several case studies discussing methods of handling arsenic containing mine wastes were obtained and reviewed. Copies of the Con mine, El Indio and Windarra Nickel/Gold Project are in Appendix I.

LOCATION	TITLE	FINDINGS
Yellowknife, NT Con Mine	Nerco Con Mine Arsenic Plant - Environmental Management Through Resource Recovery	The sale of arsenic trioxide and the recovery of gold and silver values was economically viable.
La Serena, Chile El Indio gold mine	How St. Joe Gold's El Indio Mine has Become a Major Producer of High Quality Crude Arsenic Trioxide.	Crude arsenic trioxide can be successfully produced and marketed.
Laverton, WA Windarra Nickel/ Gold Project	An Investigation of Disposal Options for Arsenic Trioxide Produced from Roasting Operations	Combining unprocessed mine tailings or calcium arsenate with portland cement appeared to be a feasible disposal option.
Yellowknife, NT Giant Mine	Truck Transfer Facility Enterprise, NT	Outlined the requirements for constructing a truck to rail transfer station.

Con Mine Case Study

- A study was carried out to determine disposal options for 70 000 tons of arsenic containing sludge stockpiled over 30 years of roaster operation. (Pg. 135)

- Chemical fixation methods, physical processing methods and resource recovery methods were evaluated on the basis of process feasibility, environmental stability and economics. Increased arsenic trioxide prices in 1980 made resource recovery feasible. (Pg. 137)

- Hot water leaching was determined to be more environmentally acceptable than a fuming process. (Pg. 137)

- A two stage counter current leach process was developed capable of treating 20 stpd of raw arsenic trioxide sludge. 12 stpd of 99.8% pure arsenic trioxide was recovered from the plant. 8 stpd of residue containing 1.2 ounces gold/ton and 3.5 ounces silver/ton was left over from the processing. The residue was stockpiled until metallurgical processes could be developed to extract the gold and silver values. (Pg. 140)

- Final inert residues were stored with mill tailings in tailings ponds. (Pg. 140)

- Process problems caused the plant to be shut down in late 1985. Solutions were developed and the plant reopened in 1987. (Pp. 141-142)

- Industrial hygiene among plant operators was a problem until a formal training program was developed. (Pg. 142)

- 5 years was the required treatment time predicted to allow full treatment of the arsenic sludge. Revenues obtained from the sale of recovered arsenic trioxide, gold and silver were projected to cover the plant's operating costs. (Pg. 142)

- To date, the treatment plant has been shut down after successfully treating all the arsenic trioxide material. A method was developed to successfully remove the gold and silver from the process residue.

<u>El Indio Gold Mine Case Study</u>

- Gold ores with a high arsenic content are processed using roaster technology. Arsenic trioxide is produced as a by-product. (Pg. 146)

- Roasting is conducted under reducing conditions to prevent the formation of less volatile pentavalent arsenates and antimoniates, loss of stable sulphide sulphur, excessive formation of oxidized iron compounds and formation of low melting point eutectics. (Pg. 150)

- Roaster gases containing sulphates of arsenic and antimony, labile sulphur and other volatiles are passed through two cyclones in parallel to remove particulate matter before being passed into a post-combustion chamber. Sufficient ambient air is admitted to completely convert all sulphates to oxides at a temperature of 750°C. (Pg. 154)

- The gases are cooled to 390±10°C and passed through an electrostatic precipitator to remove particles. Arsenic trioxide is gaseous at this temperature and passes through. (Pg. 156)

- The gas stream is cooled to 120°C in a hatch chamber and arsenic trioxide is precipitated out. (Pg. 156)

- Solid arsenic trioxide is collected in a bag house. The solids are transferred to bins beneath the baghouse and conducted via screw-feeders and elevators to storage bins. The arsenic trioxide is passed from the storage bins through Vacu-press densifiers and then into 25 and 30 gallon drums. The drums are strapped 12 or 6 to a pallet and trucked to port where they are exported in containers. (Pg. 156)

- Arsenic trioxide of an average purity of 97.3% is produced and shipped to market. (Pg. 157, Table IV)

- An increased capacity in the flotation/cyanide plant, the added value to concentrates by roasting and a strong demand for arsenic trioxide contributed to addition of a second roaster unit, to enter service in late 1989. Arsenic trioxide production would double to approximately 30 t per day. (Pg. 158)

- Arsenic trioxide production required the implementation of human and environmental controls, including air and water sampling and routine biological monitoring of staff. (Pg. 158)

- The arsenic trioxide marketing effort required about three years to refine, but sales were brought in line with production and "...El Indio feels reasonably confident that it is established as a long term supplier to the arsenic market.". (Pg. 159)

<u>Windarra Nickel/Gold Project Case Study</u>

- Investigated disposal options for arsenic trioxide only. Marketing options were considered impractical. (Pg. 347)

- Solubility testing was carried out on calcium arsenite, calcium arsenate, ferric arsenite, ferric arsenate precipitates formed from arsenic trioxide waste and on cements formed by mixing the arsenic trioxide waste or the precipitates with portland cement on its own or with additives (silica flume or flyash). (Pg. 348)

- Solubility of the precipitates was tested using the standard Multiple Extraction Procedure with a synthetic groundwater solution as the extractant. (Pg. 350)

- Calcium arsenite was found to precipitate leach much more readily than calcium arsenate. (Pg. 350) Ferric arsenite and ferric arsenate were less soluble than their calcium counterparts. (Pg. 351)

- Calcium arsenite interfered with the setting reaction of the cement, and would not harden. (Pg. 351)

- Arsenic leaching from the cement solidified products was investigated using a standard Dynamic Leach Test. Calcium arsenate and ferric arsenate mixed with cement leached much more slowly than the untreated arsenic trioxide mixed with cement. The addition of silica or flyash negatively affected the fixation of arsenic in the cement matrix and produced much higher leach rates than the straight arsenic-cement mixture. (Pp. 351-352)

- Ferric-arsenic compounds showed very low solubility but required large amounts of process chemicals. Calcium arsenate formed a low solubility precipitate but the long term stability of calcium arsenate is known to be poor. Solidification with cement appeared to be the most economically feasible disposal option. (Pp. 352-353)

Truck Transfer Facility, Enterprise NT

- Giant was involved in a program to investigate the best ways of producing and distributing a high quality WAROX product. The study examined the technical aspects of reclaiming and upgrading the product and included a market study. (Pg. 1.1)

- Upon investigating various shipping alternatives, it became clear that bulk rail shipments were easily the least expensive way to go. (Pg. 1.1)

- Giant has extensive experience in control and handling of WAROX compounds. (Pg. 1.4)

- A tentative shipping schedule called for the despatch of approximately 150 tons per week of high quality product to American markets. Based on an 80 ton payload, 1 hopper car would be loaded every four days. (Pp. 1.4-1.6)

- The product was to be in a free-flowing, dust-free granular form with a bulk density of about 90 lbs/cu. ft. (Pg. 1.6)

- Arsenic trioxide would be transported to the transfer station using trucks with a volume of approximately 1200 cu. ft. and a payload of 22 tons. The payload could be expanded to 33 tons using a "pup" trailer in the typical rig configuration. The truck would be equipped with four loading hatches and four bottom dump hoppers to be fitted with flexible boots to control dust during offloading. (Pg. 2.1)

- The arsenic trioxide would be transported from the truck to a 100 ton storage bin via a CamBelt conveyor. The CamBelt would be fully enclosed and equipped with "boots" to prevent dust losses at inlet and outlet points. The arsenic trioxide would be transferred from the storage bin to a rail car. (Pp. 2.1-2.3)

- Appendix A of the report contained emergency action measures to be taken in case of a spill at the surface arsenic load-out facility.

4.0 DATA MANAGEMENT

4.1 Economics

The information gathered from the reference sources and from telephone conversations with a number of companies indicates that the waste material with arsenic trioxide levels of 85 to 95%, is not marketable.

- 95% purity is considered low grade and is the minimum purity required for most commercial operations. 99% or higher is considered high grade could be sold to a much wider market. The price for high grade (99%) is quoted at an 8 to 12 cent per pound premium over low grade (95%) product. (U.S. Geological Survey - Minerals Information Sheet, 1996, Pg. 2).

- Some companies will take material below 95% and combine it with higher grade material to produce a blended product with a purity of 95%. (CSI, Pers. Com.)

- The iron, lead, chloride, antimony and mercury levels may have to be reduced to bring them in line with the requirements of the various companies. There is some variation in feedstock requirements however.

At a 95 to 99% arsenic trioxide purity range, the market for the material is much greater.

- The U.S. accounts for approximately 2/3 of world demand and 21 200 tons of arsenic compounds (primarily arsenic trioxide) were imported into the U.S. in 1996 with a total value of 13.4 million dollars U.S. (U.S. Geological Survey - Minerals Information Sheet, 1996, Pg. 3, Table 1)

- Overall consumption of arsenic in the U.S. has remained relatively unchanged since 1993. Wood preservatives accounted for 90% of total arsenic demand. Arsenic is converted to arsenic acid and used to produce CCA. The three primary users in the U.S. are Hickson Corp., CSI and Osmose Corp. (U.S.G.S. - Mineral Information Sheet, 1996, Pg. 1)

- Average customs value for imported arsenic trioxide (U.S.) In 1996 was 22 cents/pound, down 2 cents/pound from 1995. The decline was attributed to the lower value of some off-grade material imported from Chile used for blending with high purity material. High purity trioxide from Mexico averaged 33 cents/pound. (U.S.G.S. - Minerals Information Sheet, 1996, Pg. 2)

- China is the world's largest producer of arsenic trioxide and arsenic metal and was the largest exporter into the U.S. in 1996, accounting for 44% of U.S. demand for arsenic trioxide. (U.S.G.S. - Minerals Information Sheet, 1996, Pg. 1)

- Arsenic trioxide represents 97% of world production of arsenic.(Roskill, 1990) World production of arsenic trioxide was estimated at around 54 800 tons in 1990 (Roskills, 1990) and has dropped to an estimated at 42 100 tons in 1996. (U.S.G.S. - Minerals Information Sheet, 1996, P. 4, Table 4)

- Commercial grade arsenic trioxide was recovered from smelting or roasting of non-ferrous metal ores or concentrates in at least 18 countries. (U.S.G.S. - Mineral Information Sheet, 1996, Pg. 2)

- Canadian reported consumption of arsenic is confidential from 1992-1995, but is given as 125 tons in 1991. (Natural Resources Canada, Online Information)

- Canada exported 37 194 kg of arsenic in 1996 for a value of 54 216 $Cdn. (Statistics Canada, Online Information) The breakdown between arsenic and its compounds was not given.

Both Giant and Con mine in the N.W.T. produced arsenic trioxide in the 1980's and successfully sold the product to buyers in the U.S.

- Data indicates that arsenic trioxide was produced and sold in the N.W.T. between 1984 and 1990 for a total value of 12.6 million $Cdn. Amounts are given for 1984 to 1986 but are indicated as confidential for 1987 to 1990. (Mines and Minerals Activities, 1993, Table 12) This table indicates a value of 218 to 566 $Cdn./pound which is probably incorrect.

- Hickson received an amount of arsenic trioxide from Giant in the eighties. Sales were suspended to allow Giant to develop a process to upgrade the trioxide to a higher purity. Hickson has been "expecting to hear from Giant" regarding upgraded arsenic trioxide since then. (Pers. Com., Hickson)

- CSI expressed cautious interest in the material. Concerns were raised regarding contamination of the flue dust with other materials. (Pers. Com., CSI)

- Osmose purchased product from Con Mine during the 1980's until the Con mine plant stopped producing. (Pers. Com., Osmose Corp.)

There is currently very little if any arsenic trioxide produced for sale in Canada. Information from 1991 indicates that all arsenic trioxide produced in Canada came from the N.W.T.. The information from Statistics Canada and the 1991 Canadian Minerals Yearbook suggests that only arsenic metal is exported from Canada.

Several sources of arsenic trioxide exist in Canada, all of them are mines that produce arsenic trioxide as a by product of their metal extraction processes.

- Giant Mines has been stockpiling arsenic trioxide in underground vaults since the mine opened. Approximately 20 000 tons of this material was shipped to Hickson Corp. in the early to mid 1980's. Plans to construct a WAROX plant to upgrade the bag house dust to a 99% pure industrial product were developed starting in 1987. This project was put on hold when Royal Oak acquired the Giant Mine. (Roskill, 1990, Pg. 21)

- Dickenson Mines' Red Lake Division produced about 1 360 t of trioxide in 1985 and 1986 from its gold roasting operation. This product was exported to the U.S. (Roskill, 1990, Pp. 21- 22) Arsenic is no longer produced as a product as it is converted to ferric arsenate in an autoclave and stored. (1991 Canadian Minerals Yearbook, Pg. 9.2)

- Nerco Con Mine sold high quality arsenic trioxide to Osmose Corp. until about 1990. (Pers. Com., Osmose Corp.) Arsenic trioxide was produced using an arsenic recovery plant opened in late 1983 while the Con mine was owned by Cominco. The feed source was arsenic sludge stockpiled from the mine's opening until 1970. (Roskill, 1990, Pg. 22)

- Cominco produced an arsenic pentoxide solution at an integrated smelting and refining facility near Trail, BC until 1989. (Roskill, 1990, Page 22) Gallium arsenide was produced at Trail starting in 1981 but production stopped after a market failed to develop. (Nerco Con Mine, Annual Reports)

- Placer Dome's Campbell gold mine converts arsenic into ferric arsenate in an autoclave which is disposed of in ponds. (1991 Canadian Mineral Yearbook, Pg. 9.2)

- Equity Silver Mines Ltd. produced calcium arsenate which was disposed of in the U.S. until 1984. Currently a grade of ore with a very low arsenic content is being mined and arsenic products are not being produced. (Roskill, 1990, Pg. 23)

Arsenic is not mined as a primary product but is formed as a by-product of roasting and smelting metal ores or concentrates. Arsenic trioxide is produced in at least 18 countries. (Table 7 in App. B)

Arsenic is a very toxic substance with strict controls placed on it's handling and use. Environmental pressures have reduced the use of arsenic in several of it's traditional end uses as safer alternatives have been developed. The use of arsenic in the agricultural chemicals market (herbicides and pesticides) dropped from 20% of all arsenic consumed in the U.S. in 1990 to 4% in 1996 as alternative products became accepted. All other uses have shown a similar decline except for the wood preservative industry which has grown from 70% of all arsenic consumed in the U.S. in 1990 to 90% in 1996. (U.S.G.S. Mineral Information Sheets, 1994 to 1996, Table 2, Table 6 in App. B)

- There is a large market for arsenic trioxide as a wood preservative. The demand is therefore closely tied to the housing construction market (e.g. wooden decks). In 1988, 450 million cubic feet of lumber were treated with waterborne preservatives (98% of which was estimated to be CCA). In 1993, 470 million cubic feet were treated with waterborne preservatives (75% of all treated lumber). 500 million cubic feet were treated in 1994 with waterborne preservatives (80% of all treated wood). In 1995, 450 million cubic feet of lumber were treated with waterborne preservatives (75% of all treated wood). The apparent demand for arsenic trioxide declined slightly in 1996 despite an increase in housing starts. 1995 figures may have been influenced by a carry over from a 13% increase in housing starts in 1994. (U.S.G.S. - Minerals Information Sheet, 1996, Pages 1 to 2)

- Ammoniacal Copper Quaternary (ACQ) has recently been developed and may be an alternative to CCA as it avoids the use of both arsenic and chrome. It has yet to gain widespread usage. (U.S.G.S. Mineral Commodity Summaries, Feb. 1997, Page 2).

- A potential long term threat may be a rise in the use of galvanized steel in the home building industry. This trend, clearly evident in 1994-1995, depends significantly on the cost of lumber vs. steel and the acceptance of steel construction methods by the nation's homebuilders. (AMM online, The World Metals Information Network, 1995 report)

Approximately 215,000 tons of baghouse dust had been accumulated and stored underground at Giant mine by 1988. (Giant Report, Warox Transfer Facility) At an average collection rate from the baghouse of 12-15 tons a day (1995 Annual Report, Pg. 5) this amount will have grown to approximately 250,000 tons of material. In 1988, the material was estimated to contain 77.6% arsenic trioxide and 126, 913 ounces of gold. (Giant Resources Ltd.; Annual Report; Pg . 26) In 1995, the purity of arsenic trioxide was estimated to be between 85 and 95 wt%. The amount of gold was estimated at 0.10 - 0.15 oz/ton of dust. (1995 Annual Report, Pg. 5) The increased purity of arsenic trioxide and reduced gold content is probably due to increased efficiencies of the gold extraction and arsenic removal processes. Calculations based on these numbers put the total volume of material at 259,000 tons, containing 206,000 tons of arsenic trioxide and 132,456 ounce of gold. Based on a market price of 660 $U.S./ton (30 cent/pound) the arsenic trioxide has a value of $U.S. 136.0 million. At an exchange rate of 1 $Cdn. to 0.72 $U.S. this equates to 916 $Cdn./ton and a total value of $Cdn 188.9 million. Based on a gold price of $Cdn 300 per ounce the gold would be worth approximately $Cdn.39.7 million. These figures give total value of $Cdn.228.6 million to the product stored at Giant.

Transport costs were estimated at 40 $Cdn. per ton for rail shipment and 120 $Cdn. for truck shipment. This equates to shipment cost of $Cdn. 8 - 24 million for the entire 206,000 tons.

Con constructed a treatment facility to process approximately 7,300 tons/year of arsenic trioxide waste material, producing 4,000 tons/year of purified arsenic trioxide product. The capital cost for this facility in 1981 was $Cdn.13 million. The operating costs were estimated at less than $Cdn.650 per ton. A plant of this scale would be capable of processing Giant's current production and very little more. Giant would need to process a considerably larger volume per year to impact on the stored waste. Based on a 20 year time frame for eliminating the arsenic stored in the vaults, the processing plant would need to process approximately 12,500 tons of stored material plus 5,000 tons of currently produced material for a yearly total of 17,500 tons. Approximately 15,000 tons of arsenic trioxide product would be produced each year. Scaling Con Mine expenditures up to meet the Giant Mine requirements would mean a capital cost of $Cdn. 22 million with an operating cost of $Cdn. 650. This results in a total cost to treat and transport the current and future arsenic of $Cdn.214 million with a recovery of $Cdn.228.6 million.

World production of arsenic trioxide was estimated at 42 100 tons in 1996. (U.S.G.S. - Minerals Information Sheet, 1996, Table 4) Estimated U.S. imports of arsenic trioxide in 1996 were 29,000 tons. Based on a 20 year reduction plan, Giant would account for 60% of U.S. demand and 37% of world production, tying with China as the world's single largest producer (1996 production values).

4.2 Market Processing

The information gathered indicates that it is possible to successfully separate and market arsenic trioxide from gold mine wastes. There are two primary methods: sublimation, where the arsenic trioxide is evaporated from the waste material and then cooled to form a high purity precipitate and solvent extraction, where the arsenic is dissolved into an aqueous solution and recrystallized into a purer product. Both methods have been used successfully.

- Con Mine in the N.W.T. successfully developed a solvent extraction treatment process allowing it to treat 20 stpd of arsenic sludge from its' 70,000 ton stockpile, producing 12 stpd of 99.7% pure arsenic trioxide product. This product was shipped to Osmose Corp. in the U.S. in extra strength 45 gallon drums. The 8 stpd residue contatined 1.2 ounces gold/ton and 3.5 ounces silver/ton. The plant cost approximately 13 million dollars to build. Revenues from the sale of arsenic trioxide and the value of the recovered gold and silver were expected to cover the plant's operating costs.

- The El Indio gold mine in Chile uses a high temperature oxidation process to convert arsenic sulphates into arsenic trioxide gas. The gas is cooled and filtered through two electrostatic precipitator to remove unwanted particles and then cooled further to release arsenic trioxide crystals. Approximately 5,000 tons per year of arsenic trioxide are produced and sold on the international market.

4.3 Recovery Technology

Over 100,000 ounces of gold are estimated to be present in the arsenic trioxide waste material kept in Giant Mine's storage vaults. Recovery and sale of this gold would help offset the costs incurred during any processing of the arsenic trioxide for purification or storage purposes. The ability of Con Mine to recover the gold and silver from the residue of the arsenic trioxide upgrade process contributed to the economic viability of their processing plant.

- Several patents have been taken out on metallurgical processes to recover precious metals from tailings waste, indicating that metal recovery from tailings is possible.

- Information was obtained outlining chemical methods for recovering metals from mining wastes. Biological methods were mentioned, but specific information could not be found regarding these processes.

4.4 Materials Handling

Specific information on conveying arsenic trioxide from underground storage vaults to the surface for processing could not be found. Processes such as these must be developed on a case by case basis.

- The general feeling from communications with environmental professionals was that it would not be a very difficult operation from a technological standpoint as the material could probably be removed from the storage vaults using the reverse of the process used to transport it into the storage vaults.

- The primary concern is minimization of dust. Arsenic trioxide is a highly toxic material and may be fatal if inhaled, swallowed or absorbed through the skin.(TDG) Workers coming into direct contact would need to wear chemical protective clothing and positive pressure self-contained breathing apparatus. (TDG)

- Giant Mine has experience in the handling of arsenic trioxide material as 7,400 tons of material were shipped to U.S. buyers from 1981 to 1987. (Giant annual reports) An on site truck loading station was designed in conjunction with a study carried out by Giant in 1987-1989 on the feasibility of upgrading the arsenic trioxide for sale to wood preservative manufacturers.

4.5 Stabilization and Storage

A number of technologies are available for the on-site stabilization and storage of the arsenic trioxide waste material. The literature indicates that the most stable form of arsenic for long term storage is as a ferric arsenate compound in a process requiring a molar iron to arsenic ration of 3-4:1.

- Dickenson mine's Red Lake Division in Ontario and Placer Dome's Campbell gold mine in Ontario convert arsenic byproducts to this form and store it in ponds.

- Conversion of arsenic into calcium arsenate is no longer considered a viable disposal option as thermodynamic data indicates that the calcium reacts with carbon dioxide in the air to form calcium carbonate. The arsenic is released as a result of this conversion.

- Calcium carbonate could possibly be used if the calcium arsenate undergoes calcination at 800°C to convert the amorphous structure into a crystal structure. (Stefanakis *et al*, Pg. 290)

- Conversion into arsenic sulphide may be the most economic method as the processing can be carried out in a roaster. Giant currently operates a roaster on site to preprocess gold ores prior to cyanization treatment.

Several processes are available to encapsulate the arsenic in a cement medium. From an economic standpoint, studies have indicated this may be the most viable option.

- The U.S. government has developed a process using zeolite and portland cement.

- Stark Encapsulation markets a process under the tradename MetlCAP that claims to completely bind the arsenic particles using a mixture of chemicals and cement. The cement formed using this process can be reused as a structural material.

Other options such as phytoremediation or bioremediation show promise but are still at a developmental level.

4.6 Materials Management

Data on materials management could only be obtained from one company. Requests for information from the other sources contacted did not produce results. The values obtained indicate that offsite materials management options are very expensive, ranging from $Cdn.750 to 1600 per ton. Total costs using these processes would on the order of $Cdn. 200 to 300 million.

4.7 Other Studies

Three case studies concerning the management of arsenic trioxide mine waste were obtained and reviewed. Two of the studies, Con Mine and El Indio mine, indicated that arsenic trioxide could be processed to a sufficiently high purity level to be sold on the world market. The studies illustrated two different situations.

- In the Con Mine study, arsenic trioxide was produced after the mine's on site arsenic trioxide disposal efforts were deemed environmentally inadequate. A process was developed to produce 99.8% pure arsenic trioxide from tailings pond sludge.

- The El Indio case study demonstrated how the production and sale of arsenic trioxide can be used to maximize the profitability of a mine. The arsenic trioxide was viewed as a potential product to be developed, not merely as a waste product produced while refining gold.

The third case study did not address the prospect of purifying and marketing the arsenic trioxide beyond stating that the demand for arsenic trioxide is not high and therefore disposal options must be looked at.

- The study determined that the most insoluble forms or arsenic are also the most expensive to produce. Recommendations were made to study methods of stabilizing arsenic trioxide in a cement matrix.

During the late 1980's, Giant studied the possibility of processing the arsenic trioxide using sintered metal technology to produce a high quality product to be marketed as WAROX (White Arsenic Oxide). (1991 Canadian Minerals Yearbook, Pg. 9.1)

- All aspects of the process appear to have been considered including the construction of a truck to rail transfer facility near the community of Enterprise, NT. Communications with Hickson Inc. indicated that transport of the arsenic trioxide by rail would be a requisite part of any sales agreement. A copy of the transfer facility report was obtained from DIAND's environmental library and reviewed.

- Copies of reports detailing other aspects of the process (eg WAROX plant design, Surface Arsenic Load-Out facility) were not obtained, but could be of used in determining options for the management of Giant mine's arsenic trioxide waste material.

5.0 SUMMARY

Dillon was retained to provide a brief assessment of options for managing the arsenic trioxide contained in underground storage vaults at Giant mine in Yellowknife, NT. The study was intended to provide indications of current technologies available for all aspects of handling the waste.

The research suggests that the market for arsenic trioxide lies chiefly with the wood preservative manufacturers. The prevailing trend is to develop safer alternatives to arsenical products, but the wood preservative industry has remained consistent in its demand for arsenic trioxide. The demand for arsenic is not expected to grow much beyond current levels. Three companies contacted expressed interest in purchasing material from Giant, but marketing the large volume of material stored by the mine will require careful planning.

Osmose Corp., Hickson Corp. and CSI in the U.S. would be the most likely purchasers of any product from Giant. Hickson purchased material from Giant in the early 1980's, and Osmose purchased material from the Con mine's treatment plant until 1990 when Con's stockpile of arsenic trioxide material was exhausted. All three companies required the product to be at a minimum purity level of 95% with 99% being most favourably priced. CSI indicated that some lower grade material was purchased to blend with higher quality material but 95% was the purity most often purchased. The purification can be carried out using a hot water leach or a sublimation process. In 1981, Con chose the hot water leach process for use at its' treatment plant as they felt it was the more environmentally responsible option.

Any purification method chosen should incorporate extraction of residual gold from the arsenic containing dust. Approximately 130 000 ounces of residual gold are contained in the waste material. The economic success of the Con mine treatment plant was due in part to the successful reclamation of the residual gold and silver with the arsenic trioxide.

Accessing the material and conveying it to the surface or otherwise gaining access to it for management purposes would require careful monitoring. Arsenic trioxide is a known carcinogen, potentially fatal if inhaled or ingested and can be absorbed through the skin. Precautions would be required to minimize direct worker contact with the material and keep dust generation low. Routine biological monitoring of staff and constant air and water monitoring are required at facilities processing arsenic trioxide. Giant has had considerable experience handling arsenic trioxide and currently processes the material safely.

A number of technologies are available to render the material environmentally inert either for long term surface storage or for storage in containment vaults. Arsenic trioxide is very soluble, and must be converted to a less soluble form if contact with water is a possibility during long term storage. Iron arsenic compounds produced in an autoclave tend to be the most insoluble.

Large amounts of iron are required for the process which results in higher costs for this method. Arsenic sulphur compounds also have low solubility and have the advantage of being produced in a roaster or by biological means. Calcium arsenates are no longer considered acceptable for arsenic storage due to reactions with atmospheric carbon dioxide. The arsenic trioxide can be mixed with chemical cements to form a stable product. The cement physically and chemically binds the arsenic, rendering it unavailable to the environment. In some cases the cement can be reused for structural purposes (e.g. roadbeds). Studies have shown cement encapsulation to be the most economically viable long term disposal option.

Initial estimates for off site disposal started at $Cdn. 750.00 per ton, before considering transportation costs which range from $Cdn. 40 to 80 a ton. Considering the large volume of arsenic trioxide to be dealt with, this option is not economically feasible. The total cost for offsite disposal would be in excess of $Cdn.218 million.

Case studies indicate the material can be dealt with in several ways. One method is to convert the arsenic into a more stable form to reduce the potential environmental impact. Processing costs for this option can be high. The preferred method is to convert the arsenic trioxide into a saleable product, thereby at least partly recovering processing costs. A program is currently underway at the El Indio mine in Chile to market arsenic trioxide produced from a roaster unit. Con mine treated 70 000 tons of stockpiled arsenic trioxide sludge starting in 1981. The project ended in 1990 when the supply of arsenic trioxide was used up. During this period, the sale of arsenic trioxide combined with the value of recovered gold and silver covered the cost of operating the plant.

Table 1
Disposal Cost Summary

Disposal Method	Capital Cost (a)	Operating Cost	Transport Cost	Cost Recovery	Estimated Total Cost
Secure Landfill (b)	0	$750/ton	$40-120/ton	0	$205-225 million
Offsite Treatment (b)	0	$1600/ton	$40-120/ton	0	$425-445 million
Offsite Incineration (b)	0	$1300/ton	$40-120/ton	0	$347-368 million
Bioremediation	$20 million	$38-71/ton	$40-120/ton	0	$20-49 million
Cement Stabilization (c)	$20 million	$20-80/ton	0	0	$25-31 million
Phytoremediation (d)	N/A	$40-694/ton	0	0	$10-180 million
Ferric Arsenate (e)	$20 million	$5.09/lb of As removed	0	0	$1 684 million
Arsenic Sulphide (e)	0	$2.19/lb of As removed	0	0	$725 million
Marketing	$20 million	$650/ton	$40-120/ton	$229 million	$10-30 million profit

(a) Capital costs are based on the Con mine's treatment plant capital cost, scaled up to meet Giant's processing requirements.

(b) Off-site disposal method values were based on costs supplied by Proeco.

(c) Cement stabilization values were supplied by Stark Encapsulation.

(d) Phytoremediation capital costs are included in operating costs. Values were supplied by Phytotec Inc.

(e) Stefanakis and Kontopoulas, Pg. 289, Table II. Prices were adjusted to 1983 levels.

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Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

October 7,1997

To: **Distribution List**

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Re: **Requested Attendance for a Technical Meeting on the Management of Giant Mine's Arsenic Trioxide**

The Water Resources Division (WRD) of the Department of Indian Affairs and Northern Development (DIAND) in conjunction with the federal government, territorial government, the City of Yellowknife and Royal Oak Mines is holding a Technical Meeting of experts to review and discuss the technical aspects of management options for the arsenic trioxide stored underground at the Giant Mine site in Yellowknife, NT. The objective of this meeting is to determine, through the presentation of technical management alternatives and related discussion, viable options for the ultimate management of arsenic trioxide.

The Technical Meeting will be held on October 28, 29, and 30, 1997 in the conference facilities at Royal Oak's Giant Mine. Your attendance at this meeting is requested but should you be unavailable, I would appreciate that a representative from your department attend. This person should be familiar with the issues and be involved in the water licensing assessment and renewal process.

The focus of the technical meeting will be to, first, develop a common understanding of the history of the mine, the gold processing, the by-product (arsenic trioxide) and what are its effects. This will be accomplished, in part, with an on-site tour of Giant's mine process and arsenic storage facilities. Secondly, technical experts in the fields associated with various aspects of arsenic trioxide will provide an information base from which discussions and management options can be determined. Discussions will be formulated from smaller meeting groups that will generate opinions to be tabled with the entire technical group.

Dillon Consulting Limited has been retained to facilitate and organize this technical meeting. Should you have any questions, please contact either Gary Strong or Craig Thomas by phone (403)920-4555, fax (403)873-3328, or e-mail at yknwt@dillon.ca. Neill Thompson representing WRD-DIAND, can be contacted at (403)669-2659.

Please return a completed attendance form (attached) by October 10, 1997. A technical meeting agenda and a copy of Dillon's "Arsenic Trioxide Management Feasibility Study" are enclosed for your review.

Thank you for your consideration of this important request and we look forward to your participation.

Yours Sincerely,

David Milburn
Manager, DIAND-WRD
Attachment

Canada

ENVIRONMENTAL REGULATORY CONTROLS ON THE ONTARIO GOLD MINING INDUSTRY

The Ontario Ministry of the Environment operates from a head office in Toronto and from 5 regional offices in Kingston, Toronto, Hamilton, London, and Thunder Bay. The Northern Region, based in Thunder Bay, consists of 3 Districts, Thunder Bay/Kenora, Sudbury/Sault Ste Marie, and Timmins/North Bay, with offices in all 6 communities.

Regulatory controls on environmental discharges from the Ontario mining industry are imposed through general legislation such as the Ontario Water Resources Act and the Environmental Protection Act, regulations made under the legislation, and standards, policies and guidelines. Inherent in this legal system are the issuance of conditional "certificates of approval", generally required for each emission or discharge to the "natural environment", defined as the land, air, and water of the province. For the gold mining industry, such certificates or permits are required for the treatment, disposal and discharge of tailings effluent, minewater, and domestic sewage, for the treatment and emission of contaminants to air, such as those arising from crusher and grinding operations, refineries, and roasters, and for the disposal of solid wastes on land by either landfilling or other means.

In addition, standards for the storage and shipment of hazardous waste such as solvents and PCBs' are maintained by regulations pertaining to generator registration, system licenses and waste site and receiver permits which tie in with the national manifest system.

The following outlines some of the specific approvals and permits necessary for a gold production facility consisting of a mine and mill:

Ontario Water Resources Act (OWRA) water taking permit for process water if equipment capable of pumping greater than 50000 liters per day

OWRA tailings disposal and effluent treatment and discharge

OWRA minewater treatment and discharge

OWRA domestic sewage treatment and discharge

Environmental Protection Act (EPA) air emissions for each specific source such as crusher house exhaust, concentrate dryer exhaust, refinery stack, boiler stacks, etc.

EPA waste disposal site and system

EPA generator registration for hazardous and liquid industrial wastes

INFO that
John Bean from
MOEE will
be presenting.

Rick.

Most applications for approval for effluents and emission points from large industrial enterprises are required to undergo local public consultation followed by province wide notification through registration on the Environmental Bill of Rights (EBR) registry for a minimum of 30 days. During this period, any citizen may view the application and supporting documentation at the office which administers the approval or at the nearest local Ministry office. Public comments are invited. If the application is approved, the "decision" is further registered on the EBR for another 15 days, during which period any 2 citizens may appeal the decision to the Appeal Board, on the basis that no person in their right mind would approve such an application. If no appeal is registered which stays the approval or the Appeal Board rules against the appellant, then the approval is deemed to be valid.

Behind the official approval system, lies a regime of administrative regulations, policies and guidelines which provide guidance to both Ministry staff and the proponent on the expectations for a successful application. For instance, air emission approvals are premised on the emission rate of the contaminant being sufficiently low so to meet a point of impingement standard at a reception point, generally established as the property line. Depending on stack height, gas velocities, contaminant emission rates, distance to the reception point and climatic stabilities, an emission point may or may not be approved depending on whether or not it meets the regulated standard. For suspended particulate matter this standard is 100 micrograms per cubic meter of air over one half hour while for arsine the standard is 10 micrograms per cubic meter of air. This standard is presently being revised downward to 150 nanograms per cubic meter of air for arsenic and compounds.

For liquid discharges, minimum effluent criteria, including monitoring, have been established under Ontario Regulation 560/94:

Mine Effluent Limits- OR 560/94

Parameter	Monitoring Frequency	Daily Concentration Limit mg/l	Monthly Concentration Limit mg/l
Total cyanide	3x/week	2	1
Total susp solids	3x/week	30	15
Copper	weekly	0.6	0.3
Lead	weekly	0.4	0.2
Nickel	weekly	1	0.5
Zinc	weekly	1	0.5
Arsenic	weekly	1	0.5
Acute lethality	quarterly	>100% for rainbow trout and daphnia magna	
pH range		6.0 To	9.5

It should be noted that these are minimum requirements and are certainly not all inclusive of the contaminants which may be found in mine/mill effluents. For instance, ammonia is not specifically regulated, however limits on this specific parameter are generally placed as a condition within the approval depending on site specifics. Final effluent criteria, which may well be more stringent than the regulated standard, are established by the Ministry in consultation with the proponent, also depending on receiving stream characteristics.

The regulated limits were established after a one year monitoring program of some 67 Ontario mining effluents and a study of the best available pollution control technologies employed in areas and for ores similar to those of Ontario. For those applied to the gold mining industry, waste water control technologies in Ontario were found to be as sophisticated and varied as any throughout the world. The study identified thirteen technology trains as being capable of meeting BAT level waste water control for the gold industry, together with two additional trains for the treatment of mine water alone. A typical train might consist of natural degradation, INCO SO2 air destruction of cyanide, lime precipitation of heavy metals and ferric sulphate precipitation of arsenic, all followed by final polishing before summer seasonal discharge to the receiver.

Final effluent criteria are based on the receiving capacity of a waterbody and the Provincial Water Quality Objectives (PWQOs'), with consideration also given to the federal or provincial regulations. In the case of mining, the applicable federal regulation is the Metal Mining Liquid Effluent Regulations and Guidelines, SOR/77-178, under the Fisheries Act (which doesn't apply to gold mines) while the provincial regulation is OR 560/94, described above. If the site specific receiving water assessment determines that the effluent requirement need be more stringent that the regulated requirement, then the more stringent would be applied and enforced through the certificate of approval. On those receivers with degraded quality worse than the PWQOs', existing dischargers can be required to improve or establish treatment facilities by order, so that quality can approach or better the objectives. For those areas with water quality better than the PWQOs', the Ministry attempts to ensure that the quality is maintained at or above the objectives. The purpose of this exercise is to ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation. For arsenic, the existing PWQO is 0.1 milligrams per liter with a downward revision to 0.005 milligrams per liter awaiting approval.

The PWQOs' also relate to the management of ground water quality on the basis of protection for the greatest number of beneficial uses. Obviously, human consumption is the most important use to be protected, but there are other uses, such as agriculture, with specific water quality requirements. Where ground water is a component of streamflow, then the protection of aquatic life may also be important. Ground water contamination by seepages from tailings areas will likely become a significant component of future assessments, notwithstanding the isolated nature of many mine sites.

In some cases, the operation may be isolated and a waste disposal site may be necessary for domestic waste and some solid non-hazardous industrial waste. Again, the same public consultation and EBR requirements must be followed and a successful application would contain information on hydrogeological considerations, pre-operational ground and surface water monitoring and an operating and closure plan.

Although, strictly speaking, the provincial Environmental Assessment Act is not applicable to private enterprise, the Minister may designate a project under the terms of this Act should sufficient valid public concern express itself. One example of such a designation occurred in 1988 with the designation of the Consolidated Professor gold project at Shoal Lake on the Manitoba-Ontario border. The approving Director also carries the discretion of calling for a scoped hearing before a Hearing Board on some applications, such as an OWRA sewage works application or a waste disposal site application.

Certificates of approval may be quite lengthy, since the Ministry tries to ensure the continuance of appropriate environmental protection by placing legally enforceable conditions (supported by reasons) on each. Conditions may refer to control equipment, production rates, emission and discharge limits, both on the basis of concentrations and loadings, monitoring and reporting requirements, on-going studies, contingency plans, closure plans, and, in most cases, financial assurance to ensure compliance. Non-compliance with a condition may not only result in prosecution and penalty on conviction, but also loss of financial assurance, should the Ministry be required to undertake corrective actions. On the other hand, the proponent has the ability to appeal any condition to the Appeal Board within 15 days of issuance of the approval and the Board may vary or remove the condition, depending on the results of the appeal.

Mining operations are also regulated by the Ministry of Northern Development and Mines, which essentially enforces appropriate closure requirements through the exploration, development, production and closure stages of an operation. Before a project comes into production, a closure plan and financial assurance must be approved and filed with the Ministry. The Ministry of the Environment provides comment on the environmental components of the plan to its sister Ministry throughout the process.

Mining operations consist of large tracts of land, much of which, including a majority of the production area, could be brought into other productive uses following closure. The Ministry of the Environment provides guidance on the decommissioning of contaminated sites through a guideline recently issued in 1996. The guideline was developed to provide for the protection of human health and the environment from potential adverse effects associated with existing or future exposure to contaminated soils, sediment and groundwater. Although the mining industry is specifically exempt from the guideline, the document offers information and approaches which would certainly be useful to the industry, particularly if a closing operation wished to develop its surface property for other uses, such as cottage development.

The three approaches outlined in the contaminated site guideline for the restoration of property are titled "background", "generic", and "site specific risk assessment". The background approach involves restoration of the site to naturally occurring background levels, outlined in the Ontario typical range soil concentrations which, for arsenic, are listed as 14 micrograms per gram for agricultural uses and 17 micrograms per gram for all other uses.

The generic approach allows for the use of generic soil and groundwater criteria which are based on the effects of a contaminant on human health and/or the environment. Proponents are allowed to match certain site attributes such as land use, restoration of groundwater quality, depth of restoration and soil texture to the appropriate generic criteria. The following table lists the soil remediation criteria for arsenic for surface soils in potable and nonpotable groundwater regimes for different land uses:

Arsenic (ug/g)						Potable Groundwater Criteria ug/l
Agricultural Use		Residential/Parkland		Industrial/Commercial		All Land Uses
(25)	20	(25)	20	(50)	40	25
						Nonpotable Groundwater Criteria ug/l
"		"		"		480

( ) criterion value in brackets apply to medium and fine textured soils

It should be noted that the 25 microgram per liter criterion for potable groundwater is the drinking water objective for arsenic. Nonpotable groundwater areas are generally recognized as those where municipal distribution systems exist.

The site specific risk assessment approach includes both risk assessment and risk management considerations. These include the technical, scientific examination of the nature and magnitude of risk, including a definition of the health effects of exposure of human and ecological populations to contaminants in different exposure situations and estimating the likelihood of an event. The net result is a risk management plan which may be implemented to reduce, eliminate or block exposure pathways.

The contaminated site guideline allows for the registration of an order on title to some restored lands so that future land owners may be made aware of the previous restoration.

To review the various arsenic alert levels used in the province:

Point of impingement standard (OR 346)	10 micrograms per cubic meter of air (1/2 hour)
Arsenic and compounds	100 nanograms per cubic meter (1/2 hour)*
Ambient air quality criterion (OR 337)	25 micrograms per cubic meter of air (24 hours)
	50 nanograms per cubic meter of air (24 hours)*
	10 nanograms per cubic meter of air (annual)*
Regulated level for mine effluents	1 milligram per liter daily
	0.5 milligrams per liter monthly
PWQO	0.1 milligrams per liter
	0.005 milligrams per liter*
ODWO	0.025 milligrams per liter
Typical range soil concentrations	14 micrograms per gram (agricultural)
	17 micrograms per gram (all other uses)
Soil criteria (medium and fine textured)	25 micrograms per gram (agricultural)
	25 micrograms per gram (residential)
	50 micrograms per gram (industrial)

* Interim standard under revision

REFERENCES

Ontario Regulation 560/94

Water Management, Policies, Guidelines, Provincial Water Quality Objectives, MOEE, July, 1994

Guideline for Use at Contaminated Sites in Ontario, Revised February, 1997, MOEE

Municipal Industrial Strategy for Abatement, Best Available Pollution Control Technology, Metal Mining Sector, 2nd Ed., June 1992, MOEE

Summary of Point of Impingement Standards, Ambient Air Quality Criteria and Approvals Screening Levels, June 1994, MOEE

CAMPBELL MINE AND THE RED LAKE GOLD FIELD

Gold was first discovered in the Red Lake area, about 150 kilometers north-east of Kenora, in 1897 but it was not until the 1930s' that the first producing mine and mill began production. About a dozen mine-mill facilities operated over the years, milling over 40 million tons between 1930 and present day. Three mines remain in production; Madsen Gold Corporation, which recently reopened the property of Madsen Red Lake Gold Mines, Goldcorp, formerly known as Dickenson Mines and presently inoperative because of a long labour dispute, and the Campbell Mine of Placer Dome Inc.

Milling processes over the years included gravity separation, mercury amalgamation, flotation, roasting, cyanidation both by Merrill-Crowe and CIP methods and refining. Mercury amalgamation has not been practised for years, zinc precipitation has been replaced by CIP recovery and oxidation of refractory ore is now accomplished by pressure oxidation. However, there is evidence that at least 3 and perhaps 4 uncontrolled roasters operated in the area at one time in the 1950s' and 1960s'.

The Campbell mill was commissioned in mid-1949 and a roaster started up in 1951, coincidental with mining of higher sulphide bearing ores. The roaster operated until late 1973 with some particulate removal by cyclones and off-gases released to atmosphere through a high stack. Stack testing at that time indicated emission rates of about 12.8 British tons per day (TPD) of particulate, 19.1 TPD of SO_2 and 3.1 TPD of arsenic. Vegetation studies commissioned by the company in 1973 found that leaf damage attributable to arsenic was found on most aspen trees to a distance of 4 miles from the stack.

In November, 1973 the company started operation of a gas control system consisting of an electrostatic precipitator followed by a baghouse.to treat roaster gases. The esp was maintained at a high temperature (600 degrees F) to allow the gaseous arsenic to pass through while permitting recovery of a small amount of roasted ore dust which escaped the cyclones. Gases from the esp were cooled with ambient air to sublimate the arsenic gases which were then recovered as the trioxide by the baghouse. From November, 1973 until shut down of the roaster and start up of the autoclave in July, 1991, arsenic trioxide was pumped underground to a number of sealed abandoned stopes at about the 900 foot level. For the period between 1981 and 1987, the trioxide was sold as feedstock to other industries.

A number of options have been looked at for the possible treatment and sale of the arsenic trioxide presently in underground storage. One possibility involves the conversion of the trioxide to arsenic acid for sale to wood processors for conversion to a water treatment additive. The difficulty in this scenario is the removal of the material from underground in a manner which is both safe to the workers and of little or no environmental consequence. The company continues to assess this option. The company also plans to assess the groundwater/surface water impacts of permanently sealing the material underground before flooding the mine on closure. Should the mine suffer premature closure before all the information on the above two options has been collected, the company plans on maintaining the mine in a dry state to the 900 foot level and directing minewater to the tailings area.

Stack testing following start up of the new system indicated arsenic emission rates in roaster off gases had been reduced to about 0.006 TPD; sulphur dioxide levels remained about the same as earlier, although a new after burner had been installed to push gases higher into the atmosphere. Vegetation studies undertaken in 1974 showed that arsenic leaf damage had been eliminated although further work undertaken in 1975 showed a substantially greater degree of SO2 damage when compared to the 1973 work. Because annual vegetation damage attributable to continued SO2 emissions was consistently evident in the neighbouring mine community of Balmertown, the company undertook a voluntary emission reduction program beginning in 1983. This involved roaster shut downs during periods when wind direction and speed would carry roaster gases over the community during the summer growing season.

When the autoclave began operation in 1991, ferric arsenate tailings from the oxidation system were handled separately from other tailings streams and disposed in a segregated, artificially lined pond. Testing of pond effluent showed minimal arsenic levels and the pond was later decommissioned in 1994. Autoclave tailings are now disposed of in the primary disposal area.

Early tailings disposal and effluent treatment systems at Campbell Mine were to a nearby lake and swamp. In 1965, tailings were discharged to the south west bay of Balmer Lake, which discharges to the Chukuni River via Balmer Creek, a total distance of some 5 kilometers. Tailings from the Goldcorp mill discharge to a bay at the south east corner of the lake. From a small one tank system to add lime to roaster quench water in 1976 and virtually an uncontrolled discharge of tailings to Balmer Lake, the Campbell disposal and treatment system has expanded to include ferric sulphate precipitation of arsenic, lime precipitation of heavy metals and SO2-air destruction of cyanide. Besides in plant tankage, reactors and clarifiers, external systems include a primary disposal area of some 30 years capacity, primary and secondary clearwater ponds, followed by a further large retention settling and polishing pond system before final seasonal discharge to Balmer Lake. Water reuse is practised to the extent possible.

Effluent quality complies with certified requirements, although the company has difficulty with occasional ammonia levels and daphnia toxicity. Loading levels of arsenic in the discharge from Balmer Lake presently average about 2400 kilograms per year compared to 11000 kilograms per year in 1991. For the equivalent period of time, the discharge from the Campbell system to the lake contained 14 kilograms of arsenic, obviously demonstrating the continuing loading impact created by the former direct discharge of tailings from both Campbell and Dickenson into the waterbody.

As a matter of interest, arsenic in abandoned Red Lake area tailings are typically in the 4000 ppm range and liquid drainages from these can average from 0.1 to 0.6 milligrams per liter, not much different than what would be expected today in effluent from a well controlled and treated tailings system. However, except for waters in the immediate receiving stream below Campbell Mine and the Goldcorp operation, waters in the Red Lake area are considered to be of good quality. In addition, mercury concentrations in walleye are fairly typical of the species obtained from pristine lakes in Northwestern Ontario, while arsenic concentrations are at least an order of magnitude lower than the maximum allowable limit for consumption.

REFERENCES

A Chemical and Biological Assessment of Waters Impacted by Gold Mining Operations in the Red Lake Area, August, 1982, MOEE

The Chemical Characteristics of Mineral Tailings in the Province of Ontario, 1979, MOEE

Air Quality, Northwestern Ontario, Annual Report, 1987, MOEE

Environmental Monitoring Report, 1971-1975, Campbell Red Lake Mines Limited, Pollutech Pollution Advisory Services Limited

Personal Communication, D. Hiller, Placer Dome Inc., Campbell Mine

MEMORANDUM

ROYAL OAK MINE INC. - NWT DIVISION GIANT MINE
JOHN STARD, MINE MANAGER
[redacted]

TO: JOINT OCCUPATIONAL HEALTH & SAFETY COMMITTEE MEMBERS

FROM: JOHN STARD

SUBJECT: ARSENIC TRIOXIDE MANAGEMENT

DATE: OCTOBER 22, 1997

Please find attached the agenda for the Arsenic Trioxide Management Meeting with the Joint Occupational Health & Safety Committee that is scheduled for October 27, 1997 starting at 2:00 pm at the administration office. (upstairs)

Thank You

Royal Oak Mines Inc.
MEMORANDUM

To: John Stard, Manager, Giant Mine

From: Richard Allan, Manager - Mining Projects

Date: October 21st, 1997

Subject: **O H & S Meeting - Arsenic Trioxide Management**

The following is an agenda for the meeting with the Occupational Health and Safety Committee, scheduled for October 27th, at 2:00 pm. The suggested time for the meeting is from 2:00 to 4:00pm. Terry Pepper, Metallurgist from Highwood Resources, and Sue Lendrum of Royal Oak Corporate, will be arriving on the 1:00pm flight, and will be available to participate.

Agenda:

Introductions (committee, and invitee's)	(J. Stard)
Upcoming Arsenic Trioxide Management Meeting (Co-sponsored with DIAND)	(R. Allan)
Giant Mines' Storage Practice and Status	(R. Allan)
Arsenic Trioxide Management Plan (Tentative future plans)	(R. Allan)
Upgrading / Reprocessing Options	(T. Pepper)
Marketing Opportunities	(S. Lendrum)
Open Discussion and Comments	

Management Representatives:

Rob Moore	Co-Chairman
Bruce Graney	Safety - Alternate
Kent Morton	Mill
Al Goetz	Maintenance
Dave Powers	Safety
Don Patterson	Mine
Ted Bienias	Mine

Labour Representatives:

Wayne Campbell	Co-Chairman
Rick Cassidy	Mill
Alex Mikus	Mechanic
Terry Regimbald	Mine
Steve Peterson	Alternate Co-Chairman
Don McNenly	Mill
Craig Janz	M.E.G.

Neutral Representative:

Ben Nordahn	Worker Rep.

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

DISTRIBUTION AND ATTENDEES LIST
October 28, 29, and 30, 1997

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DATE: October 7, 1997

FIRM	CONTACT	FAX NO.
Royal Oak Mines Inc. NWT Division	John Stard Stephen Schultz Kent Morton	873-2980 873-2914 920-2627
Project Dev. Group	David Donison	920-2133
Corporate Office	Rick Allen	(206) 822-3552
Technical Expert	Sue Lendrum Serena Domville	873-2980 (206) 822-3552
Environment Canada	Ed Collins Steve Harbicht	873-8185
MACA	Terry Brookes	920-6156
H&SS	Andre Corriveau Frank Hamilton Dr. Syvain Chouinard	873-0442 873-7706 920-4271
WCB - Mines	Sylvester Wong Peter Bengts	873-0262
MacKenzie Regional Health	Brad Colpitts	920-4015
City of Yellowknife	Neil Jamieson Adrian Bader	920-5668
DIAND	Jim McCaul Neill Thompson Shannon Pagotto Dave Nutter Len Hedburg Brenda Kuzyk	669-2716 669-2716 669-2716 669-2715 669-2720 669-2701
Dept. Fisheries & Oceans	Ron Allen Maria Healy	873-8871
Miramar Con Mine	Mikko Nyyssonen Brian Labadie	920-7068

Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

October 7,1997

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Re: Requested Attendance for a Technical Meeting on the Management of Giant Mine's Arsenic Trioxide

The Water Resources Division (WRD) of the Department of Indian Affairs and Northern Development (DIAND) in conjunction with the federal government, territorial government, the City of Yellowknife and Royal Oak Mines is holding a Technical Meeting of experts to review and discuss the technical aspects of management options for the arsenic trioxide stored underground at the Giant Mine site in Yellowknife, NT. The objective of this meeting is to determine, through the presentation of technical management alternatives and related discussion, viable options for the ultimate management of arsenic trioxide.

The Technical Meeting will be held on October 28, 29, and 30, 1997 in the conference facilities at Royal Oak's Giant Mine. Your attendance at this meeting is requested but should you be unavailable, I would appreciate that a representative from your department attend. This person should be familiar with the issues and be involved in the water licensing assessment and renewal process.

The focus of the technical meeting will be to, first, develop a common understanding of the history of the mine, the gold processing, the by-product (arsenic trioxide) and what are its effects. This will be accomplished, in part, with an on-site tour of Giant's mine process and arsenic storage facilities. Secondly, technical experts in the fields associated with various aspects of arsenic trioxide will provide an information base from which discussions and management options can be determined. Discussions will be formulated from smaller meeting groups that will generate opinions to be tabled with the entire technical group.

Dillon Consulting Limited has been retained to facilitate and organize this technical meeting. Should you have any questions, please contact either Gary Strong or Craig Thomas by phone (403)920-4555, fax (403)873-3328, or e-mail at yknwt@dillon.ca. Neill Thompson representing WRD-DIAND, can be contacted at (403)669-2659.

Please return a completed attendance form (attached) by October 10, 1997. A technical meeting agenda and a copy of Dillon's "Arsenic Trioxide Management Feasibility Study" are enclosed for your review.

Thank you for your consideration of this important request and we look forward to your participation.

Yours Sincerely,

David Milburn
Manager, DIAND-WRD
Attachment

Canada

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

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October 28, 29 and 30, 1997

Royal Oak Mines Inc.,		**NWT Division:**	John Stard, Mine Manager
			Stephen Schultz, Environmental Manager
			Kent Morton, Mill Superintendent
		Project Dev Group:	David Donison, Mine Engineer
		Corporate Office:	Rick Allan, Manager, Mining Projects
		Technical Expert:	Sue Lendrum, Project Geologist
			Serena Domville, Environmental Consultant
Environment Canada:,		**Yellowknife:**	Ed Collins, Chief, Environmental Engineering
			Steve Harbicht, Chief, Assessment/Monitoring
GNWT:	**RWED-**	**EPS:**	Emery Paquin
		MO&G:	________
	MACA:		Denis Adams,
	H&SS:		Andre Corriveau
			Frank Hamilton,
			Dr. Sylvain Chouinard,
	WCB-	**Mines:**	Sylvester Wong,
			Peter Bengts
MacKenzie Regional Health Services:			Brad Colpitts, Public Health Officer
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			Adrian Bader, Manager Public Works
DIAND:	**WRD-**		Jim McCaul, Head, Regulatory Approvals
			Neill Thompson, Pollution Control Specialist
			Shannon Pagotto,
	Minerals-		Dave Nutter,
	District-		Len Hedburg,
	E&C-		Brenda Kuzyk,
DFO:			Ron Allen, Head, Fisheries and Approvals
			Maria Healy, Habitat Specialist
Highwood Resources:		**Technical Expert:**	Terry Pepper, Metallurgist
Westmar Consulting:		**Technical Expert:**	Tony Willacy, Materials Handling Specialist
Phillips Industrial:		**Technical Expert:**	Terry Quinn, Waste Management Specialist
Royal Military College:		**Technical Expert:**	Ken Reimer Environmental Effects
University of Alabama:		**Technical Expert:**	Dr. Martin G. Bakker, Professor of Chemistry
Weber State University:		**Technical Expert:**	Dr. Jack Adams, Bioremediation
Hatch Consulting:		**Technical Expert:**	Holgar Krutzelmann, Mineral Processing
Campbell Red Lake Mine:			Dave Hiller, Environmental Superintendent
MOEE:		**Ontario:**	________
Atomic Energy Control Limited:			Dr. Gary Thome
NHRI:			Dr. John Gibson
Miramar Con Mine:			Mikko Nyyssonen, Environmental Manager
			Brian Labadie, VP Operations

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE, N.W.T.

TECHNICAL MEETING ATTENDANCE FORM

October 28, 29 and 30, 1997

Location: **Royal Oak's Giant Mine Conference Facilities, Yellowknife, N.W.T.**

____

Name of Attendee

____

Agency

It is assumed that you will be attending all three days.
Please confirm.

I WILL BE / I WILL NOT BE ATTENDING DAY 1 (The Mine Tour)
Please Circle One.

PLEASE RETURN TO **DILLON CONSULTING LIMITED.**
Fax (403) 873-3328

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 1:

08:00 **Registration**

08:20 **Introduction**
Dave Clark, Dillon Consulting Limited
David Milburn, Director, WRD-DIAND

08:45 **Giant Mine History and Current Practices**
Rick Allan (Project Manager), John Stard (Mine Manager), Kent Morton (Mine Operations) Royal Oak Mines

09:30 **What is Arsenic Trioxide and What are its Effects?**
Serena Domville, forms and chemistry of arsenic, environment and health;
Bill Cullen, arsenic and the environment
Dr. Sylvain Chouinard, health effects of arsenic

10:45 **Coffee Break**

11:00 **Mine Facility Brief and Tours**
Rick Allan, Royal Oak Mines; 3 tour groups to be formed of 8-10 people.
1. Surface tour - general plant and mine facilities.
2. Mill tour - process tour from crushing to roaster to baghouse.
3. Underground tour - storage facilities.

12:00 approx. **Lunch** - To be served between tours

13:00 **Mine Facility Tours Continued**
Giant Mine Staff

15:30 **Meeting Venue Shift to Royal Oak Guest Lodge**
Light snacks and refreshments provided

16:00 **Regulatory Overview**
Dave Clark, Dillon Consulting Limited; Water Licence
Laurie Bruce, Dillon Consulting Limited; CEAA

17:00 **The Economics of Arsenic Trioxide.**
Sue Lendrum, Royal Oak

17:45 **Day 1 Summary and Closure**
Dave Clark, Dillon Consulting Limited

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 2:

08:30 **Opening Comments, Day 2 Agenda and Introductions**
Dave Clark, Dillon Consulting Limited

09:00 **Underground Storage of Arsenic Trioxide**
Rick Allan, Royal Oak; Overview, history and storage rationale.

10:15 **Coffee Break**

10:30 **Transport and Handling of Arsenic Trioxide.**
Tony Willacy, Westmar Consulting; Surface handling.
Dave Donison, Royal Oak; Underground removal methods.
Terry Quinn, Phillips Industrial Services; Hazardous waste transport.

12:00 **Lunch-** Tranquilla Treatment - EMR Microwave Technology

13:00 **Material Processing/Upgrading as an Economic Commodity**
Terry Pepper, Highwood Resources
Kent Morton, Giant WAROX, Royal Oak

14:30 **Material Processing/Stabilization/Neutralization as an Uneconomic Waste**
Dr. Martin G. Bakker, University of Alabama, Zeolite-Hydraulic Cement

Coffee Break

Dr. Jack Adams, Centre for Bioremediation, Weber State University

16:00 **Case Studies**
Dave Hiller, Campbell Red Lake Mine an Ontario experience
MOEE regulatory experience
Holgar Krutzelmann, Hatch Consulting
Brian Labadie, Miramar Con Mine Experience

17:30 **Day 2 Summary**
Dave Clark, Dillon Consulting Limited

18:30 **Informal Discussion and Social**
Explorer Hotel Hospitality Suite Sponsored by Dillon Consulting

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 3:

08:30 **Opening Comments and Day 2 Review**
Dave Clark, Dillon Consulting Limited

08:45 **Working Group Sessions**
Group facilitators from Dillon Consulting
3 to 4 working group discussions to identify the issues and concerns i.e., underground storage, environmental impact, process, economics and viable management options.

10:15 **Coffee Break**

10:30 **Meeting Group Session**
Facilitators reports and total meeting group discussions to determine main management options and issues.

12:00 **Lunch**

13:00 **Working Group Sessions**
Group facilitators from Dillon Consulting
3 to 4 working group discussions based on task assigned issues from morning sessions and development of recommendations based on assigned management options or issues.

14:45 **Meeting Group Session**
Facilitators reports and total meeting group discussions to determine main management options and issues.

15:15 **Coffee Break**

15:30 **Technical Meeting Conclusions/Recommendations**
Dave Clark, Dillon Consulting Limited; Open Session Discussions

16:45 **Closing Comments**
David Livingstone, DIAND

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

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Hatch Consulting:		**Technical Expert:**	Holgar Krutzelmann, Mineral Processing
MOEE:		**Ontario:**	--------------
Atomic Energy Control Limited:			Dr. Gary Thorne
NHRI:			Dr. John Gibson

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ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE, N.W.T.

TECHNICAL MEETING ATTENDANCE FORM

October 28, 29 and 30, 1997

Location: **Royal Oak's Giant Mine Conference Facilities, Yellowknife, N.W.T.**

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Name of Attendee

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Agency

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Please Circle One.

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Dillon Consulting
Limited

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

DRAFT

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 1:

08:00 **Registration**

08:20 **Introduction**
Dave Clark, Dillon Consulting Limited
David Milburn, Director, WRD-DIAND

08:45 **Giant Mine History and Current Practices**
Rick Allan (Project Manager), John Stard (Mine Manager), Kent Morton (Mine Operations) Royal Oak Mines

09:30 **What is Arsenic Trioxide and What are its Effects?**
Serena Domville, forms and chemistry of arsenic, environment and health;
Bill Cullen, arsenic and the environment
Dr. Sylvain Chouinard, health effects of arsenic

10:45 **Coffee Break**

11:00 **Mine Facility Brief and Tours**
Rick Allan, Royal Oak Mines; 3 tour groups to be formed of 8-10 people.
1. Surface tour - general plant and mine facilities.
2. Mill tour - process tour from crushing to roaster to baghouse.
3. Underground tour - storage facilities.

12:00 approx. **Lunch -** To be served between tours

13:00 **Mine Facility Tours Continued**
Giant Mine Staff

15:30 **Meeting Venue Shift to Royal Oak Guest Lodge**
Light snacks and refreshments provided

16:00 **Regulatory Overview**
Dave Clark, Dillon Consulting Limited; Water Licence
Laurie Bruce, Dillon Consulting Limited; CEAA

17:00 **The Economics of Arsenic Trioxide.**
Sue Lendrum, Royal Oak

17:45 **Day 1 Summary and Closure**
Dave Clark, Dillon Consulting Limited

ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

DRAFT

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 2:

08:30 **Opening Comments, Day 2 Agenda and Introductions**
Dave Clark, Dillon Consulting Limited

09:00 **Underground Storage of Arsenic Trioxide**
Rick Allan, Royal Oak; Overview, history and storage rationale.

10:15 **Coffee Break**

10:30 **Transport and Handling of Arsenic Trioxide.**
Tony Willacy, Westmar Consulting; Surface handling.
Dave Donison, Royal Oak; Underground removal methods.
Terry Quinn, Phillips Industrial Services; Hazardous waste transport.

12:00 **Lunch-** Tranquilla Treatment - EMR Microwave Technology

13:00 **Material Processing/Upgrading as an Economic Commodity**
Terry Pepper, Highwood Resources
Kent Morton, Giant WAROX, Royal Oak

14:30 **Material Processing/Stabilization/Neutralization as an Uneconomic Waste**
Dr. Martin G. Bakker, University of Alabama, Zeolite-Hydraulic Cement

Coffee Break

Dr. Jack Adams, Centre for Bioremediation, Weber State University

16:00 **Case Studies**
Dave Hiller, Campbell Red Lake Mine an Ontario experience
MOEE regulatory experience
Holgar Krutzelmann, Hatch Consulting
Brian Labadie, Miramar Con Mine Experience

17:30 **Day 2 Summary**
Dave Clark, Dillon Consulting Limited

18:30 **Informal Discussion and Social**
Explorer Hotel Hospitality Suite Sponsored by Dillon Consulting

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ARSENIC TRIOXIDE MANAGEMENT
GIANT MINE, YELLOWKNIFE N.W.T.

TECHNICAL MEETING AGENDA
October 28, 29 and 30, 1997

Location: Royal Oak Giant Mine's Main Office Meeting Facilities, Yellowknife NWT.

Day 3:

08:30 **Opening Comments and Day 2 Review**
Dave Clark, Dillon Consulting Limited

08:45 **Working Group Sessions**
Group facilitators from Dillon Consulting
3 to 4 working group discussions to identify the issues and concerns i.e., underground storage, environmental impact, process, economics and viable management options.

10:15 **Coffee Break**

10:30 **Meeting Group Session**
Facilitators reports and total meeting group discussions to determine main management options and issues.

12:00 **Lunch**

13:00 **Working Group Sessions**
Group facilitators from Dillon Consulting
3 to 4 working group discussions based on task assigned issues from morning sessions and development of recommendations based on assigned management options or issues.

14:45 **Meeting Group Session**
Facilitators reports and total meeting group discussions to determine main management options and issues.

15:15 **Coffee Break**

15:30 **Technical Meeting Conclusions/Recommendations**
Dave Clark, Dillon Consulting Limited; Open Session Discussions

16:45 **Closing Comments**
David Livingstone, DIAND

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Attention Financial/Business Editors:

EMR MICROWAVE PRESIDENT & CEO DELIVERING PAPER AT CIM CONFERENCE IN VANCOUVER

FREDERICTON, NB, March 7 /CNW/ - EMR Microwave Technology Corporation (``EMR'') (EMW - ASE) announces that on 27 April 1997 its President and CEO, Dr. J. M. Tranquilla, will be delivering a paper entitled ``Mineral Extraction and the Use of Microwave'' at the CIM Conference being held in Vancouver. The conference is being hosted by the Canadian Mining, Metallurgy and Petroleum Institute.

The paper focuses on the advantages of using microwave-based technology in the extraction process of gold and other metals, compared to current technology used in the industry.

Dr. Tranquilla states that preliminary energy utilization tests indicate that EMR's microwave technology offers significant capital and operating cost advantages in the treatment of refractory ores, including gold, silver, platinum, and copper as well as most other base and precious metals. He also adds that the technology leads to processes which do not produce toxic byproducts such as sulphur dioxide and arsenic oxides, and that the technology should enable the lowering of economic cutoff grades at many existing mines and the lowering of the break-even point on ore bodies not yet in production.

The paper will also summarize the findings of independent consultants and preliminary findings generated in commercial pilot projects.

THE ALBERTA STOCK EXCHANGE HAS NEITHER APPROVED NOR DISAPPROVED OF THE CONTENT OF THIS PRESS RELEASE.

-30-

For further information: Micheline Gaudet, Manager Investor Relations, Marketing, Tel: (506) 459-4334; Fax: (506) 459-4345 CHARLIE ~~[illegible]~~ / THORNTON 3000.00 TESTING DEFRACTORY RAYS ICP ANALYSIS

EMR MICROWAVE TECHNOLOGY CORPORATION has 20 releases in this database.

VIEW OTHERS

NON DISCLOSURE

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Attention Financial/Business Editors:

EMR MICROWAVE CORPORATION - QUARTERLY REVIEW: 1 DECEMBER 1996 - 28 FEBRUARY 1997

FREDERICTON, N.B., March 5 /CNW/ - EMR Microwave Technology Corporation (`EMR') (EMW-ASE) is pleased to release a review of current and projected activities in the following areas:

- Pretreatment Processes For Precious Metal Extraction
- Heavy Oil Extraction
- Environmental Reclamation in Kuwait
- Investor Relations
- Corporate Finance

BACKGROUNDER

PRETREATMENT PROCESSES FOR PRECIOUS METAL EXTRACTION

Minex Joint Venture

EMR announced on 13 December 1996 a Memorandum of Understanding with Minex Resources LLC of Phoenix, Arizona to joint venture on Minex's gold and platinum ore deposits in Arizona. The MOU reflected EMR's interest in the project as a net profit participation equal to half of the improvement in potential realizable value of the reserves brought by EMR's technology, and in any case not less than a minimum 10% net profit participation. In the course of due diligence and finalizing the necessary legal agreements, the parties have changed the EMR participation to be, again, one half of the enhancement but to a minimum 8.8% gross royalty. On the previously announced 600,000 tons of reserves, assayed at 1.5 ounces per ton gold equivalent, EMR's undiscounted share of the reserves is worth about $38 million Cdn at a gold price of $355 per ounce. Also, EMR's on site due diligence has revealed that the reserves are substantially greater than 600,000 tons. The true extent of these reserves is unknown at present, however the parties will confirm the quantities by independent survey prior to commercial production.

By the end of February 1997 EMR had completed its portion of the pretreatment system design, Minex was moving equipment on site to commence pilot production of concentrate and commercial production is scheduled for early August 1997. Commercial production is planned to reach 150 tons per day by year end with an ultimate one-unit production target of 350 tons per day by the end of the first quarter of 1998.

Pilot Plant For The Pretreatment Of Refractory Gold Ore

EMR is nearing completion of its large scale pilot plant to treat refractory ore and concentrate by the use of microwave energy. The plant is located in a 6,000 sq. ft. facility on the outskirts of Fredericton, N.B. The fluidized bed microwave reactor is designed to process a minimum of 2.5 tonnes per day of concentrate. The process has been successfully demonstrated on EMR's laboratory pilot system and the company will use its large scale pilot facility to demonstrate commercial feasibility using feedstock from Goldcorp's Red Lake mine.

Other Issues

Although delayed by other priories, EMR continues to negotiate with a major mining equipment manufacturer on rights to utilize EMR's technology and to assist in the scale-up to large systems. EMR believes that agreement in principle has been reached and that a definitive agreement will soon be signed.

The Colorado Minerals Research Institute joint project will see the construction of a pilot facility utilizing EMR's microwave system in conjunction with CMRI's complete pilot and laboratory infrastructure located in the heart of North America's gold mining industry. This facility will combine EMR's microwave system and process expertise with CMRI's well known metallurgical expertise, thereby greatly enhancing EMR's commercial piloting and process development capability. CMRI is already a well established and highly respected supplier of assaying and piloting services to the international mining industry. Construction of this pilot facility is underway, with EMR's equipment scheduled for installation by April 1997.

Continuing Development of Mineral Extraction Processes

Microwave extraction process development is continuing on more than a dozen different ore bodies including copper, gold and platinum group metals. Because the chemistry of each ore body is unique, it is necessary to customize each treatment process, often involving design and development of new applicators or reactors. EMR's personnel complement of 27 persons, including 6 at the Ph.D. level, is organized into several highly integrated working groups which are proving capable of attacking and quickly resolving very complex technical problems.

HEAVY OIL EXTRACTION

EMR has met its deliverable objectives in its agreement with Imperial Oil with respect to the Cold Lake bituminous oil project. At this stage, Imperial Oil is assessing the economic viability of a multi-well pilot of the microwave enhanced recovery technology. Meanwhile, Rovert Wilson, EMR's Vice President of Oil Operations, is continuing to seek joint venture opportunities in non-bituminous heavy oil. Ongoing reservoir modelling indicates that EMR's microwave stimulation technique will substantially reduce production costs and greatly enhance reserve recovery of heavy oil.

ENVIRONMENTAL RECLAMATION IN KUWAIT

EMR has long recognized the potential use of its microwave technology to remediate mining sites of process byproducts such as sulphidic tailings. At the invitation of the government of Kuwait, EMR's President, Dr. Tranquilla, led a technical team to Kuwait in June 1996 to investigate the potential utilization of microwave techniques to reclaim the oil saturated remains of over 460 oil lakes created at the close of the Gulf War. Several hundred kilograms of sample material arrived in October 1996 and were successfully treated in the laboratory. EMR subsequently responded to a Request For Proposals from the Oil Ministry of the Government of Kuwait and accepted an invitation to make a formal presentation on 8 March 1997 in Kuwait City. If the Proposal is accepted, EMR will have the opportunity to prove the technique in a six month demonstration project which would commence immediately. EMR recognizes that there are several risks associated with such a project; the technical risk is considered high and there is the security risk of large quantities of unexploded ordnance. EMR would not be directly involved in ordnance handling but would contract this service to recognized experts. Consequently, if it proceeds, EMR intends to source risk financing for this project outside of its shareholder equity. If such financing cannot be obtained, the project will not proceed. Ultimately, financing for any full scale operation would be by means of a long term cleanup contract between the Kuwaiti government and EMR or its technology transferee.

INVESTOR RELATIONS

EMR is expanding and improving its Investor Relations program. In this direction, the company is pleased to announce the appointment of Micheline

Gaudet as Manager of Investor Relations.

Micheline has a Bachelor of Commerce degree from Dalhousie University, is fully bilingual and comes to us with ten years of experience with a major New Brunswick company.

EMR is focusing on increasing the company's visibility in the investment community. In January, the company developed a comprehensive computer based presentation package to take EMR's story to the market. During March and April 1997 this presentation will be given to over 200 public market and investment brokers in Atlantic Canada. Following this initiative, the company will target selected Canadian and United States small-cap funds. The immediate objectives of this market strategy are to inform the market of EMR's long term potential and to build a stable base of long term shareholders.

EMR's Internet web site is under construction and will debut in May. This site is designed to provide up to date investor information including press releases, project status reports, quarterly financial statements and annual reports.

CORPORATE FINANCE

EMR is still several months away from being able to generate significant cash flow from the commercialization of its technology. Consequently, since traditional financing is not available, the company is funding its operations by issue of capital stock. In fact, EMR is presently in the process of raising up to $3,000,000 through the issue of up to 6,000,000 common shares at $0.50 each. Each share purchased will entitle the purchaser to a warrant for another share at $0.60 each for up to two years from the date of issue. The placement is expected to close by 15 April 1997.

In the year ended 31 December 1996, EMR was totally an enterprise in the development stage. Financing amounting to $2,409,000 was raised by issue of common shares, of which $2,114,000 was utilized in the development of the company's technology. Cash on hand at 31 December 1996 was $390,000, an increase of $296,000 from the previous year.

Staffing at year end amounted to 23 persons, including 5 Ph.D.s, a significant increase from one year earlier.

Besides continuing its R&D efforts for several months, EMR intends to advance approximately $1.3 million from its placement funds to the Minex project, secured by the ore body and subject to a rate of return of 40%. These advances will be repayable at the rate of one third of free cash flow from operations and are expected to be fully repaid by the end of the first year of Minex's commercial operation. As well, $700,000 will be utilized for the capital cost of the Fredericton Pilot Plant. The company anticipates that the additional financing necessary for future operations will come from the exercise of outstanding options and warrants, operations and royalty financing which EMR believes it will be able to access upon successful commissioning of the Minex operation.

The Alberta Stock Exchange has neither approved nor disapproved of the contents of this release.

%SEDAR: 00000602E

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For further information: Micheline Gaudet, Manager, Investor Relations, Tel: (506) 444-8704; Fax: (506) 459-4345, E-Mail: mgaudet(at)emrmicrowave.com

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

<u>Figure 1</u>

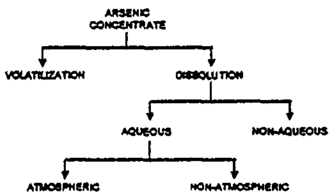
Arsenic Concentrate Impurities

COMPONENT	CUSTOMER SPECIFICATIONS	ARSENIC CONCENTRATE CONTENT
As2O3	99.0 - 99.5%	85 - 95%
Sb (Antimony)	0.05 - 0.30%	1.6%
Fe (Iron)	0.025 - 0.03%	0.8%
Cu (Copper)	0.001 - 0.1%	0.01%

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

<u>Figure 2</u>

Technology Options



ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

<u>Figure 3</u>

High Temperature Technology Theory

MATERIAL	EVAPORATION TEMPERATURE (°C)
As_2O_3 - Arsenic	193
Sb_2O_3 - Antimony	1550
Fe_2O_3 - Iron	?
Cu_2O - Copper	1026 & 1800 - loses O

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

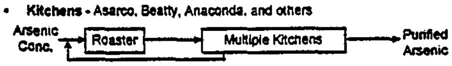
Figure 4
High Temperature Technologies - Key Elements

- Evaporate arsenic trioxide (As_2O_3)
- Separate arsenic fumes from entrained impurities
  - Settling chamber
  - Baghouse
  - Sintered metal filters
- Condense purified arsenic trioxide
  - Brick cooling chambers (kitchens)
  - Air-cooled condensors
  - Cold-air quenching

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 5
High Temperature Technologies - Examples

- **Kitchens** - Asarco, Beatty, Anaconda, and others



- **Air-Cooled Baffles** - Ashio (Japan)

- **Cold-Air Injection** - Giant WAROX Process

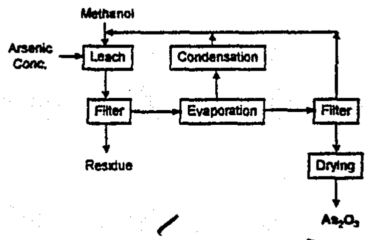
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 6
High Temperature Technologies - Sb Elimination

- As-Sb Solid Solutions
  - As_2O_3-Sb_2O_4 in solids
  - As_2O_3-Sb_2O_3 in vapor
- Results of Solid Solutions
  - As_2O_3 removal from solids is incomplete
  - Sb_2O_3 contamination of recovered As_2O_3
- Possible Process
  - Cool by stages to drop As_2O_3-Sb_2O_4
  - Recover pure As_2O_3 in second cooling stage

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 7
Non-Aqueous Dissolution Technologies - Methanol



antimony?
Sb and Fe not dissolved.

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

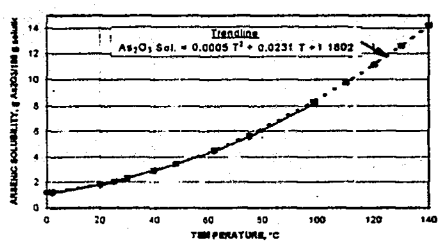
Figure 8
Non-Aqueous Dissolution Technologies - Methanol

- **BENEFITS**
  - High Arsenic Solubility (about 42 g As/L at 60°C)
  - High Selectivity (Sb & Fe at or near limit of detection)
  - Rapid Arsenic Dissolution
  - Reduced heating/evaporation cost
    - Heat of Vaporization 263 cal/g vs. 590 cal/g for water
    - Heat Capacity 0.566 cal/g-°C vs 1 000 cal/g-°C for water
- **LIABILITIES**
  - Potential Health & Safety Concerns
  - New Technology
    - Development Time
    - Financial Risk
    - Technical Risk

no air emission.

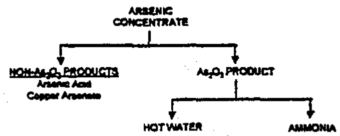
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 9
Non-Atmospheric Aqueous Dissolution Technologies



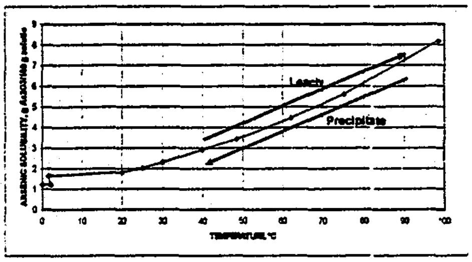
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 10
Atmospheric Aqueous Dissolution Technology Options



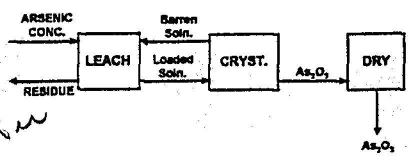
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 11
Atmospheric Aqueous Dissolution - Hot Water Leach Basis



ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 12
Atmospheric Aqueous Dissolution - Hot Water Leach Flowsheet



ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 13
Atmospheric Aqueous Dissolution - Hot Water Leach

- **BENEFITS**
  - Demonstrated on plant-scale
  - Uses standard equipment
  - Potentially high arsenic recovery 95% +
- **LIABILITIES**
  - Plant experience was of operating difficulties
  - Antimony specification difficult to meet
  - Questions about gold recovery from residue

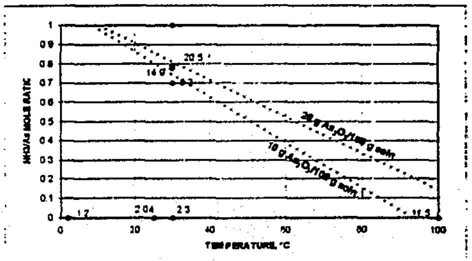
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 14
Atmospheric Aqueous Dissolution - Hot Water Leach
Testwork Goal - Impurity Removal

- Impurity Problems (antimony & iron)
- Purification Methods
  - Partial neutralization (NaOH, CaO, NH_3)
    - Some Sb removal without As
    - Material balance poor
    - Concern about cations
  - Oxychloride formation
    - Thermodynamics limited
    - Some Sb removal without As
    - Material balance poor
  - Other (Working on disclosure)

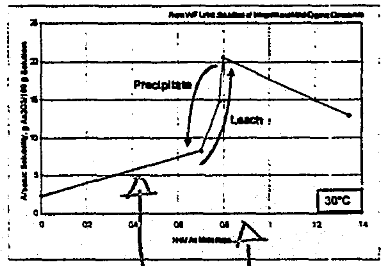
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 15
Atmospheric Aqueous Dissolution - NH_3 Leach Basis



ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 16
Atmospheric Aqueous Dissolution - NH_3 Leach Basis

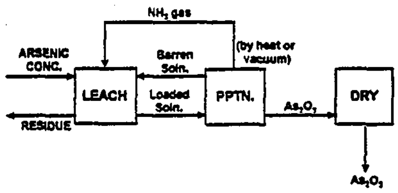


ppt. leach

remove NH_3 for pptn.

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 17
Atmospheric Aqueous Dissolution - NH_3 Leach Flowsheet



ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 18
Atmospheric Aqueous Dissolution - NH_3 Leach

- **BENEFITS**
  - High arsenic solubility
  - Iron exclusion
  - Potentially high arsenic recovery
- **LIABILITIES**
  - Cost of equipment and training for ammonia handling
  - Lack of information about antimony chemistry
  - New Technology
    - Development Time
    - Financial Risk
    - Technical Risk

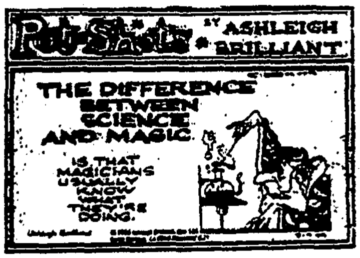
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 19
Atmospheric Aqueous Dissolution - NH_3 Leach Testwork

- **GOALS**
  - Low energy cost
  - High arsenic recovery
  - Antimony exclusion
- **TEST RESULTS**
  - Arsenic solubility —
  - Antimony solubility —
  - New technology —

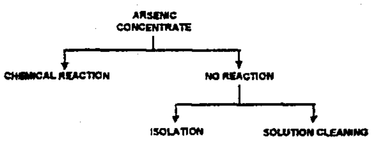
ARSENIC TRIOXIDE MANAGEMENT
PROCESSING TECHNOLOGIES

Figure 20
Philosophy



ARSENIC TRIOXIDE MANAGEMENT
FIXATION TECHNOLOGIES

Figure 1
Technology Options



ARSENIC TRIOXIDE MANAGEMENT
FIXATION TECHNOLOGIES

Figure 2
Technology Options - Chemical Reaction

- **Arsenic Sulfide - As_2S_3**
  - Oxidizes and dissolves
  - Possibly fix in cement
  - Possibly stable in anaerobic conditions with sufficient biomass
- **Calcium Arsenate - $Ca_3(AsO_4)_2 \cdot 3H_2O$**
  - Not stable with respect to atmospheric carbon dioxide
- **Ferric Arsenate - $FeAsO_4 \cdot 2H_2O$**
  - Precipitation above 90°C best
    - Crystalline material
    - Solubility 2 orders of magnitude lower than amorphous material

bog / marsh plants + water

gel.

ARSENIC TRIOXIDE MANAGEMENT
FIXATION TECHNOLOGIES

Figure 3
Technology Options - Isolation

- **Portland Cement**
  - Exposed arsenic may still dissolve
  - Water penetration of cement may dissolve internal material
- **Cement with Additives (sodium silicate, polymers, etc.)**
  - Stabilize by incapsulation
  - Limit moisture penetration

ARSENIC TRIOXIDE MANAGEMENT
FIXATION TECHNOLOGIES

Figure 4
Technology Options - Solution Cleaning

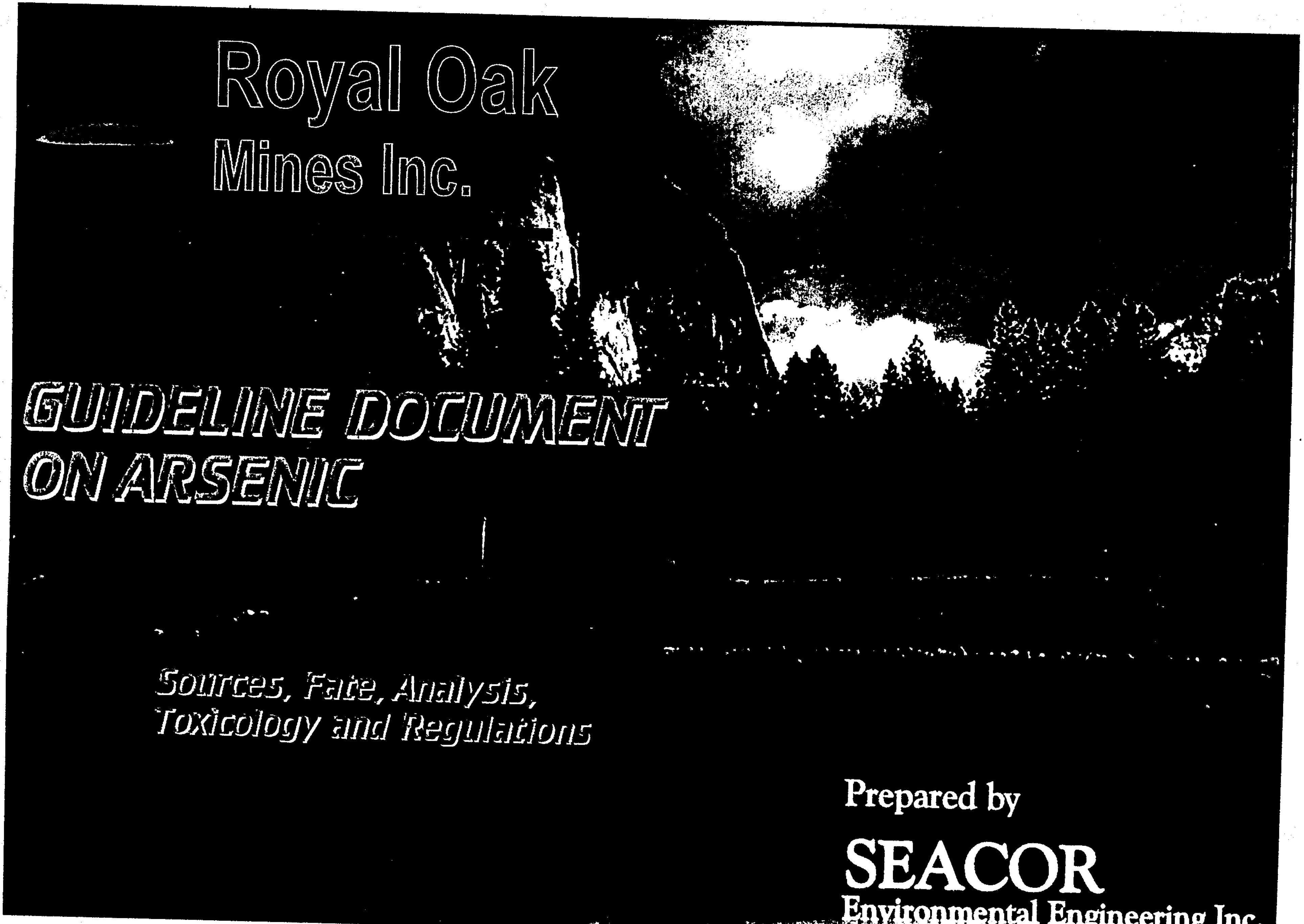
- **Fly Ash with or without Cement**
  - Acts with residual carbon in ash
  - Aborbs any arsenic which dissolves
  - Has a saturation point
- **Zeolite with or without Cement**
  - Absorbs dissolved species into silicate matrix
  - Aborbs any arsenic which dissolves
  - Has a saturation point

Silicate rings w/ fine carbon

ARSENIC TRIOXIDE MANAGEMENT
PROCESSING OPTION

Figure 1
Treatment Decision

Stabilize	Purify
• Benefits	• Benefits
– Proven technology	– Salable Product
– Plant at Con Mine	– Recoverable gold
• Liabilities	• Liabilities
– Operating cost to Con	– New technology
– No cost recovery	– Construction costs
– Material still around	– Start-up & op, costs



Royal Oak Mines Inc.

GUIDELINE DOCUMENT ON ARSENIC

Sources, Fate, Analysis, Toxicology and Regulations

Prepared by

SEACOR
Environmental Engineering Inc.

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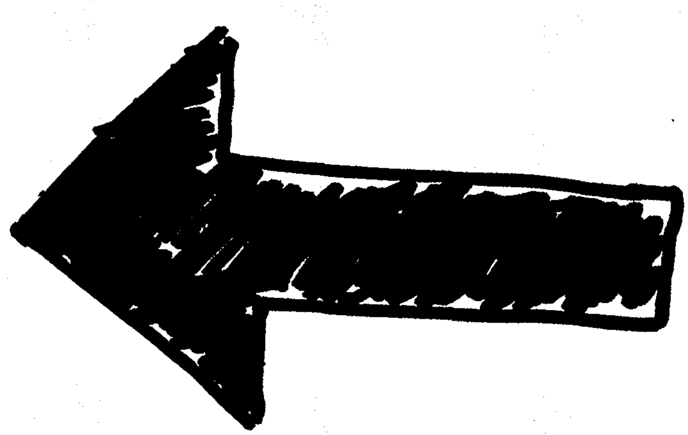
Arsenic Trioxide Management Workshop

Giant Mine
October 28, 29, 30



facsimile
TRANSMITTAL

to: Larry Connell
Environmental Manager
Royal Oak Mines

fax: (425) 822-3552

date: September 2, 1997

pages: 1 Pages, including this cover sheet.

Subject: Arsenic Trioxide Management Workshop

Larry: The idea of the workshop has taken hold. Let's talk about getting things started. Some initial items to confirm is: Is ROM still interested. Who is the contact. What is ROM's level of involvement (funding, experts, presentations). What ROM's thoughts are on timing, an organizing group and how the workshop should be structured and facilitated. Don McDonald is interested and available but has some definite time block problems (expecting a baby).

Call me as soon as you can.

From the desk of...

Neill Thompson
Pollution Control Specialist
Water Resources Division
Indian and Northern Affairs Canada
Box 1500
4914 - 50 th Street
Yellowknife NT X1A 2R3
Ph: (403) 669-2658
Fax: (403) 669-2716
thompsonn@inac.gc.ca

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FAX

Kemess Mines Inc.

SITE PHONE: (604) 524-5324 SITE FAX: (604) 522-3519

To:	John STARD	From:	Larry Connell
Fax:	403 [illegible] 669 - 9424	Pages:	2
Phone:		Date:	Sept 04 /97
Re:	Workshop on U/G Storage & As.	CC:	Rick Allan

☐ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply ☐ Please Recycle

• Comments:

Please find attached a fax received yesterday from Neil Thompson at DIAND Water Resources regarding a proposed workshop format to discuss the U/G Storage of Arsenic Trioxide at the Giant mine.

Tim Acton and I were approached by DIAND on this issue back in July. We both see it as an excellent way to discuss the options for U/G Storage of As with community leaders away from press scrutiny and in a non-confrontational venue. It is an excellent opportunity to educate community leaders and to flesh out the issues ahead of the public hearing.

Larry Connell

Royal Oak
Mines Inc.

NWT Division - Giant Mine
PO Bag 3000, Yellowknife NT X1A 2M2
Phone: 403-669-3702 Fax: 403-873-2980

# of Pages including cover: 3

FAX TO: Kent Nator / S. Schultz. ✓

FAX NO:

FROM: Marilyn for J. Stard

DATE:

RE:

for your info

Royal Oak Mines Inc.

NWT Division - Giant Mine
PO Bag 3000, Yellowknife NT X1A 2M2
Phone: 403-669-3702 Fax: 403-873-2980

# of Pages including cover: 20

FAX TO: Kirk Allan / S. Schultz

FAX NO:

FROM: Marilyn Hooler for J. Staus

DATE: Sept 19/97

RE: Draft Workshop Outline

facsimile TRANSMITTAL

to:	Sylvester Wong - WCB	873-0262
	Ed Collins - EP	873-8185
	Ken Hall - EPS, GNWT	873-0221
	Dennis Adams/Terry Brookes - MACA, GNWT	920-6156
	Andre Corriveau - YK H&SS, GNWT	873-0442
	Neil Jamieson - C of YK	920-5668
	John Stard, ROM	873-2980
	c: Brad Colpitts - MRHS	920-4015
	Jim McCaul - DIAND	
fax:		

date: September 18, 1997

pages: (~~18~~) Pages, including this cover sheet. (19) (17)

Subject: Draft Workshop Outline

Attached is a draft workshop outline, task list and information list to be discussed at the next meeting on September 26 at Giant Mine at 0900 hrs.

We need to have a number of issues resolved in order to keep on track.

N

From the desk of...

Neill Thompson
Pollution Control Specialist
Water Resources Division
Indian and Northern Affairs Canada
Box 1500
4914 - 50 th Street
Yellowknife NT X1A 2R3
Ph: (403) 669-2659
Fax: (403) 669-2716
thompsonn@inac.gc.ca

DRAFT

DRAFT GIANT MINE ARSENIC TRIOXIDE MANAGEMENT WORKSHOP

Objective: A venue for affected parties to review and discuss the technical aspects of management options for the arsenic trioxide stored underground at the Giant Mine site. The workshop should provide a common background and technical understanding of management options for the upcoming NWT Water Licensing process.

Background: Gold at the Giant Mine is contained in an arsenopyrite ore. In the milling of the gold, arsenic trioxide and sulphur dioxide are released to through a roasting process. The majority of the arsenic trioxide is captured and is currently stored underground, while the sulphur dioxide and a small portion of the arsenic trioxide are released into the air through the roaster stack.

The Department's of Environment Canada and Health Canada developed and recently held a workshop to discuss "Controlling Arsenic Releases into the Environment in the Northwest Territories" in response to a CEPA Parliamentary Committee Review recommendation. The workshop primarily looked at airborne releases of arsenic; however there was a great deal of concern expressed over the underground arsenic trioxide. In addition, the workshop was attended by all sectors having an interest including: regulatory/government agencies, Royal Oak Mines, labour unions, health associations, ENGOs, aboriginal groups and concerned citizens. It was conducted in a spirit of cooperation rather than confrontation and was appreciated by most groups.

The Giant Mine water license expires on March 31, 1998 and one of the major issues of environmental, public and health concerns involves the management and ultimate disposal of the approximately 270,000 tonnes of arsenic trioxide stored underground in a series of storage vaults.

There is a general feeling that the abandonment of arsenic trioxide underground is not as an acceptable practise as it perhaps was in the past. This is due to growing environmental and public health awareness and concerns and the unknown technical factors such as mine flooding, vault seepage and permafrost conditions.

There was a general feeling that a workshop, similar to the Environment Canada workshop, be held to address the underground arsenic trioxide issue.

A meeting was held with Royal Oak Mines, Environment Canada, DIAND, City of Yellowknife, WCB, MACA - GNWT, RWED - GNWT and Health and Social Services - GNWT to discuss the issue. At the meeting the following items were developed:

- a workshop outline was developed (attached)
- agencies provided their level of support for the workshop and a member on the organizing committee (attached)
- agreement on facilitation and approximate dates

NEXT MEETING: Friday, September 26, 0900 Hrs at Giant Mine site.

DRAFT

WORKSHOP ORGANIZING COMMITTEE AND LEVEL OF SUPPORT

WCB - Peter Bengts - experts attendance, support??
Environment Canada - Ed Collins - experts attendance, support??
City of Yellowknife - no representative - provide $5K.
RWED - no representative - provide for a lunch or support for an aboriginal group's participation.
Health and Social Services - Frank Hamilton - arrange for arsenic health expert
Royal Oak Mines - John Stard, Rick Allen - experts, tour, workshop/facilitation costs
DIAND - Neill Thompson - workshop/facilitation costs

FACILITATION AND DATES

The group agreed that Don MacDonald would be the facilitator and Don had expressed interest in the project subject to his busy business and domestic schedule. In a later conversation with Don he expressed his concern as being the primary facilitator/organizer because of his schedule and suggested we should seek another lead facilitator. Don suggested that Mr. Heijo Versteig would be a competent facilitator as he had done the Base metal smelting consultation. Don also suggested the two facilitators that accompanied him at the Environment Canada workshop, Janet Stavinga and Lynn Hunter. Don would be available as a facilitator and could arrange some cooperative project with Heijo.

Attached are the CVs of these people.

ACTION: A decision needs to be made at the next meeting on who to proceed with as well as any other technical support they may need. People are invited to suggest other qualified persons and should bring CVs to the Friday, September 26 meeting.

We need to decide on a workshop structure of presentation, panels and/or break-out groups.

The suggested dates were either November 12,13 & 14 or November 19, 20 & 21. The Explorer is not available at all. Other choices are the YK Inn and Northern United Place. Again a decision is required on the date and location. This is subject to who the facilitators are as well.

DRAFT

WORKSHOP OUTLINE/AGENDA

Day 1

Introduction:

- History of the mine, process and arsenic storage (Royal Oak)

(- Why it came to be stored underground? Can anybody answer that? CPHA)

- General chemical, health and environmental background of arsenic and arsenic trioxide. (Experts to be found - Serena Domville? Bill Cullen - UBC?, Ken Reimer - RMC?, Andre Corriveau - H&SS?)

- Market situation for arsenic trioxide (Royal Oak)

Regulatory Overview:

- DIAND - Water License
- MACA - Land lease
- Environment Canada - CEPA, Fisheries Act?
- DFO - Fisheries Act?
- RWED - EPA
- WCB - Mine Safety Act, OH&S issues
- H&SS - public health issues

Underground and Surface tour of the arsenic trioxide related facilities at Giant Mine.

Closure/Summary/Tomorrow

DAY 2 & 3 Technical Review/Discussion of Management Options:

The technical discussion format should a consider a mix of expert presentation, panel discussion and break out groups. Discussions on the options should focus on their pros/cons, risks, technological state of development, OH&S and environmental issues/benefits, economic feasibility, further work/testing/evaluation required and overall likelihood for success. Discussions may not be able to come up with a single recommendation for a single process but it will serve to bring the benefits and drawbacks of any process to a point where some may be more feasible than others.

Leave Underground:

1) abandon in place
    - studies underway
    - hydrology and time to flood workings

2) keep workings dry by pumping
    - requirements to do this in perpetuity, facilities required.

DRAFT

Physical Movement of the Material to Surface and Emptying Vaults
- Access to vaults
- Methods of removal and movement to surface
- OH&S Issues
- Residual and managing empty vaults

Processing/Upgrading the Material as a Commodity:
- consider recovery of arsenic trioxide alone and with gold (&silver?)
- need to define specific options/processes and experts

Stabilize/Neutralize/Dispose of the Material as an Uneconomic Waste
- define options and obtain experts.

Case Studies:
- Giant WAROX and previous sales
- Con - arsenic plant & autoclave
- Campbell & Dickenson at Red Lake, Ont from an operational and regulatory perspective.
- Barrick's El Indio Mine in Chile.

Either representatives from the group or someone capable who has researched the projects.

DAY 3:

Summary of Options

Some form of debate or panel?

Further work required?

Development of recommendations?

How do we close?

DRAFT

ACTION ITEMS:

- Choose facilitators plus any support, dates and site.
- Finalize support and organizing group.
- Begin selection of processes and case studies to be discussed. ROM needs to provide the processes/options they are and have looked at. Others need to identify processes that are within the possible, also from the Dillon study.
- Identify and select experts - use free expertise (government, industry) as much as possible.
- Finalize workshop agenda and format
- Develop a schedule and timelines
- Develop a participant list. This should be done in conjunction with a decision on the size of the workshop. 20, 30? Possibly a discussion on the size of the EP workshop and its' effectiveness. Ed to provide Environment Canada's.

NEXT MEETING: Friday, September 26, 0900 Hrs at Giant Mine site.

HAJO VERSTEEG B.A. LL.B. M.JUR.

ENVIRONMENTAL LAW AND POLICY ADVISOR

Mr. Neil Thompson
Water Resources Division
DIAND
Yellowknife NWT

Hi Neil
Further to our discussion, here are some preliminary thoughts on how you should consider managing your multistakeholder consultation. Generally, there are 11 categories/themes that process managers must consider, as follows:

- -workshop goals/objectives
- -participants, speakers
- -logistics(workshop venue, hotel arrangements, food, Etc.)
- -information management(always a big task)
- -workshop outputs
- -contents & production of workshop briefing binder
- -milestones
- -pre-workshop bilateral contacts with stakeholders (a big & very important job)
- budget
- -miscellaneous (media strategy, extra-curricular activities, etc.)

Planning is the key to success. The process manager must carefully address human, financial, and time constraints, and must build the appropriate team to deliver the workshop. Flexibility to quickly accommodate changing circumstances is essential.

If I was asked to design and deliver the workshop (produce and implement the 11 themes for a 2 day multistakeholder workshop for app. 50 people) I would very generally estimate my costs as follows:

- -professional fee, est. 30-35 working days (25 billable days) ...$22,500.00 +GST
- -all administrative costs .... 4'500.00 +GST
- -travel & accomodations (2 trips to Yellowknife).....................3,500.00

I would be pleased to provide you with a more refined proposal following further detailed discussions, if you want to pursue this matter further with me. In any event, I wish you the best in your deliberations.

Yours truly

Hajo Versteeg

5365 HILLTOP DR., MANOTICK, ONT CANADA K4M 1G4
TEL: (613) 692-4837 FAX: (613) 692-0410

From: Hajo Versteeg <versteeg@magi.com>
To: NT.REGION(ThompsonN)
Date: 9/18/97 9:54am

HAJO VERSTEEG CURRICULUM VITAE

ADDRESS 5365 Hilltop Drive
Manotick, Ontario
Canada K4M 1G4
Tel: (613) 692-4837
Fax: (613) 692-0410
E-mail: versteeg@magi.com

CITIZENSHIP Canadian

EDUCATION

University of Western Ontario, London, Canada:
Bachelor of Arts, 1973
Bachelor of Laws, 1976

University of Auckland, New Zealand:
Master of Jurisprudence (in Environmental Law),1978
(Fowlds Prize as the most distinguished graduating student).

AREAS OF SPECIALIZATION

* Environmental law and policy analysis(domestic and international);

* Design and implementation of public and multi-stakeholder consultation processes, workshops and conferences(domestic and international);

* Training seminars on environmental law and policy.

EMPLOYMENT HISTORY

1991 to Environmental Law and Policy Advisor
present Representative Contracts-greater detail available upon request

* Mar. - Apr. 1997: Assisted in the design, and facilitated an intergovernmental workshop for the Canadian Council of Ministers of the Environment to draft a plan of action for developing Canada-wide standards for seven identified priority substances;

* Jan.1997: Assisted in the design, presented and developed the proceedings of a one-week Workshop in Chile to provide information exchange between Chile and Canada on water quality management, including pollution prevention initiatives in Canada;

* Jan.-Apr.1997: Member of a project team from Resource Futures International to assist Environment Canada in defining processes needed to set criteria for pollution prevention planning;

HAJO VERSTEEG
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* Sept. 1996 - June 1997: Assisted in the design and administration, and facilitated a multi-stakeholder Strategic Options Process for the Canadian Base Metals Smelting Sector. The exercise produced a strong concensus report for the Federal Ministers of Environment and Health recommending options for reducing the releases of six substances declared toxic by the Canadian Environmental Protection Act ;

* Aug. 1996: Assisted in the design, and facilitated an Environmental Effects Monitoring Information Management Workshop with Environment Canada and the pulp and paper industry;

* Mar. - July 1996: On contract to World Health Organization (WHO) to assist in the design and implementation of the Intergovernmental Forum on Chemical Safety Experts Meeting on Global Action on Persistent Organic Pollutants (POPs). This meeting was held in June 1996 in Manila. The meeting adopted recommendations on international action for POPs which were accepted by the United Nations Environment Programme and the WHO in early 1997;

* Feb. - Mar. 1996: Assisted in the design, and facilitated a multi-stakeholder workshop that produced the Final Report of the Assessment of the Aquatic Effects of Mining in Canada (Aquamin);

* Jan. - Feb. 1996: Under contract to the Department of Indian Affairs and Northern Development, authored a Background Paper on Envirommental Contaminents in the Arctic, for presentation to the Second Conference of Parliamentarians of the Arctic Region;

* Jan. 1992 - Feb.1996: Short-term policy advisor to the government of the Philippines to provide recommendations on ways to improve pesticide law and policy. The job included: designing and implementing a process to ensure that parties interested in pest management in the Philippines helped shape the recommendations; liaison with multinational chemical industry, senior bureaucrats and politicians, international donor and aid agencies, and ENGOs; writing the Final Recommendations; and, assisting in their implementation, including advice on amending current law and policy. The project was sponsored by the Canadian International Development Agency. The majority of the work was conducted in the Philippines (2 - 4 week visits, 3-4 times per year);

* Oct. 1994 - Sept. 1995: Assisted in the design and implementation of a global workshop on persistent organic pollutants (POPs), sponsored by Environment Canada and the Republic of the Philippines. Duties included: overseeing the production of a Background Report on POPs (with contributions from 50 authors from around the world) and writing several sections, including the legal aspects of POPs; overseeing the selection of the delegates (more than 140 individuals from 40 countries); and overseeing the administration of the meeting, including facilitation and follow-up;

* May 1995: Assisted in the design and facilitation of a multi-stakeholder consultation on metal mining liquid effluent regulations;

HAJO VERSTEEG
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* April 1995: Assisted in the design and facilitation of a multi-stakeholder consultation on the Federal (Canadian) Pollution Prevention Strategy;

* Oct. 1994: Resource person at the annual meeting of the Regional Network on Safe Pesticide Production and Information for Asia and the Pacific (RENPAP), sponsored by the United Nations Development Programme and the United Nations International Development Organization, Oct. 25 -31, Nantong, China;

* Aug. - Oct. 1994: Assisted in design and implementation of an international ecotoxicology workshop held in the Philippines. Presenter and resource person at the workshop, Oct. 17- 19, Tagatay City, the Philippines;

* Apr. - Jul. 1994: Author of the Pollution Prevention Issues Elaboration Paper presented by Environment Canada to the Parliamentary Standing Committee on Environment reviewing the Canadian Environmental Protection Act;

* May 1994: Coordinator and senior instructor for one week workshop in Guatemala on the development of environmental law and policy in Central America, sponsored by the International Development Law Institute;

* Feb. - Mar. 1994: Report for Environment Canada on a draft Federal Pollution Prevention Strategy;

* Feb. - Oct. 1993: Designer and facilitator for a multi-stakeholder consultation on developing a national pollution prevention legislative framework, sponsored by Environment Canada. Task Force members included representatives from ENGOs, labour, industry and federal and provincial governments;

* Nov. 1992 - Mar. 1993: Report for Environment Canada on a legal analysis of the pollution prevention provisions in the Canadian Environmental Protection Act;

* Sept. - Dec. 1992: Member of Project Team of the Keystone Centre in Colorado, U.S.A. to design an International multi-stakeholder consultation on toxic hazards in less developed countries.

1989 to 1991 Executive Secretary, Canadian Pesticide Registration Review (job description on request).

1985 to 1989 Chairman, Federal Pest Management Advisory Board (job description on request).

1980 to 1985 Law Professor, Faculty of Law, University of New Brunswick (taught Environmental, Natural Resources and Criminal Law).

AFFILIATIONS

* Member, Barristers' Society of New Brunswick and Canadian Bar Association;

HAJO VERSTEEG 4

REPORTS AND PUBLICATIONS

Author of numerous publications on environmental and natural resources law and policy, environmental risk management, and the law/science interface (all titles and copies available upon request). A sampling follows:

Versteeg, H. Persistent Organic Pollutants: Socio-Economic Considerations for Global Action Theme Paper for the Intergovernmental Forum on Chemical Safety Experts Meeting held in June 1996, Manila. Document No. IFCS/Exp.POPs2, 28 May 1996, 40 pp.;

Versteeg, H. Environmental Contaminents in the Arctic Theme Paper prepared for the Second Conference of Parliamentarians of the Arctic Region, held in Yellowknife in March, 1996 - Published Proceedings: Environment Canada: bilingual, 33 pp.;

Versteeg, H. (principal editor and author) Meeting Background Report : International Experts Meeting Towards Global Action On Persistent Organic Pollutants (Revised Oct. 1995) Environment Canada, 600 pp.;

Versteeg, H. Reviewing CEPA : The Issues #7 - Pollution Prevention (1994) Environment Canada - Bilingual, 43 pp.;

Versteeg, H. Final Report Examining the Current and Proposed Potential of the Canadian Environmental Protection Act to Incorporate Pollution Prevention Principles and Strategies (1993) Environment Canada - Bilingual, 95 pp.;

Versteeg, H. Final Report Recommending Ways to Improve Pesticide Policy in the Philippines (1992), 65 pp.;

Versteeg, H. Public Consultation: A Comprehensive Practice Manual printed by the Canadian Centre for Management Development in two volumes, (Ottawa, 1992);

Versteeg, H. "Intervenor Funding: The Alachlor Review Board Experience" 3 Canadian Journal of Administrative Law and Practice (Carswell Company Ltd., Agincourt, 1989), 91-101;

Versteeg, H. "Toxic Torts: Epidemiology and Toxicology versus Burden of Proof" Canadian Institute for Administration of Justice (Halifax, 1988 - published proceedings);

Versteeg, H. "The Protection of Endangered Species: A Canadian Perspective", 11 Ecology Law Quarterly (University of California, at Berkeley, 1984), 267-304;

Spitzer, W., H. Versteeg, et al., New Brunswick Task Force on the Environment and Cancer, Final Report, Commissioned by the Government of New Brunswick (1984). 140 pp.;

Versteeg, H. "Environmental Risk Assessment: A Rational Approach to the Management of New Brunswick's Spruce Budworm Enigma" 11 Canadian Environmental Law Reports (1982), 109-121;

HAJO VERSTEEG 5

Versteeg, H. "The International and National Response to the Problems of Marine Pollution" 3 Auckland University Law Review (1978), 209-242 (Winner of Auck. U.L.R.Prize).

CONFERENCE PAPERS

Numerous papers and/or participation in national and international conferences, symposia and roundtables (complete listing available upon request). A sampling follows:

Association of Southeast Asian Nations Senior Officials On The Environment Meeting, Bali, Indonesia (Sept., 1995): Paper - International and Regional Implications of Persistent Organic Pollutants;

Industrial Vegetation Management Association of Alberta, Banff, Canada (Mar., 1995): Keynote Speaker - Due Diligence: A Preventative Approach for Reducing Liability;

United Nations Industrial Development Organization : Workshop on Industrial and Occupational Health and Safety, Davao City, the Philippines (Dec., 1994) Resource Person and Paper - Environmental Risk Assessment and Management : A Developing World Perspective;

International Conference on Forest Vegetation Management, Auburn, Alabama (April, 1992): Paper - Forest Pest Management Research Needs into the 21st Century;

Organization for Economic Cooperation and Development, and Executive Office of the President of the United States, Washington, D.C. (Jan., 1990): Risk and Regulation: From Assessment to Communication: Workshop participant;

Symposium on the Impact of Pesticide Use in Developing Countries; International Development Research Centre, Ottawa (Sept., 1990): Paper - Consensus Building in Regulating Risk Activities - Possible Options for Developing Countries;

Federal Republic of Germany, Federal Ministry of Food, Agriculture and Forestry, Braunschweig, West Germany (Aug., 1988): Paper - The Canadian Pest Management Regulatory System;

Dioxin '88 Symposium, Umea, Sweden (Aug., 1988) Paper - Scientists as Expert Witnesses in Toxic Tort Litigation;

Dioxin '87 Symposium, Las Vegas (Oct., 1987): Paper - Alternative Dispute Resolution: A Canadian Perspective;

REFERENCES

On request

Lynn Hunter
#11 - 630 Huxley Street,
Victoria, B.C. V8Z 3X8
Phone (250)479-0937 Fax(250) 479-9154
email: lhunter@pacificcoast.net

Faxcover

To: Neill Thompson, Indian and Northern Affairs, Canada (403) 669-2716

From: Lynn Hunter

Date: September 16, 1997

Number of Pages: __3__

Comments:

Don MacDonald requested I send you my resume in preparation for a possible workshop on arsenic releases to be held this November in Yellowknife.

I hope the workshop comes about and look forward to seeing Yellowknife once again.

Lynn Hunter

LYNN HUNTER

#11 - 630 Huxley Street,
Victoria, B.C. V8Z 3X8
email: lhunter@pacificcoast.net

(250) 479-0937
fax (250) 479-9154

PROFILE

An executive-level advocate with extensive national and international experience. A dynamic, results-oriented leader with excellent inter-personal and communication skills along with conflict resolution, meeting facilitation and project management capabilities.

CAREER HIGHLIGHTS

Contract Work

B.C. Government Employees Union and the Ministry of Human Resources (1994)
- interpersonal dispute resolution case

Environment Canada (1997)
- facilitated multi-stakeholder meetings in Yellowknife, NWT on the issue of arsenic releases from the Giant Mine

David Suzuki Foundation (1997)
- outreach and media work on the issue of salmon netcage farming

Co - Chair Pacific Salmon Alliance — **August 1996 to Present**

Pacific Salmon Alliance, a non-governmental salmon conservation and community development organization working with First Nations, coastal communities, academics, environmentalists and fishermen and women.

- Liaise with other non-governmental organizations, governments, communities and individuals to do policy development, research and public education with the goal of achieving sustainability in the Pacific salmon fishery.

Coordinator, The Wild Salmon Coalition — **January 1995 - July 1996**

The Wild Salmon Coaltion, a diverse group of British Columbia non-governmental organizations concerned with wild salmon conservation.

- Raise funds to support the work of the member organizations;
- Facilitate coalition building, policy development and campaigning;
- Promote effective government and media relations.

Member of Parliament, Saanich - Gulf Islands **1988 - 1993**
Associate Environment Critic

Elected Member of Parliament and active participant on several national and international committees and delegations, including:

- **Parliamentary Environment Committee** member. The committee worked to focus public attention on environmental issues.
- **Conference on the Environment and Development (Rio Earth Summit)** member, Canadian Delegation. This was the largest gathering ever, of national representatives to study tensions between human development, population and the environment.
- **Western Hemispheric Parliamentary Conference (Quito, Ecuador)** member. A meeting of elected leaders throughout the Western Hemisphere to review issues and create recommendations on human population and development issues.
- **Constitutional Renewal (Beaudoin-Edwards and Beaudoin-Dobbie) Parliamentary Committees** member. Two multi-party travelling committees to consult with Canadians on Constitutional reform.
- **External Affairs Canada - Debt Crisis Committee,** delegate to New York and Washington multi-party meetings, leading to a consensus recommendation to the Canadian government for a course of action on the international debt crisis.
- **Mission for Peace - El Salvador,** Canadian delegate to observe the country during the 1989 Presidential election.

OXFAM Canada, Vancouver Island Coordinator **1985 - 1988**

OXFAM is a Canadian non-governmental organization providing guidance, support and financial assistance to human development projects internationally.

- Managed Vancouver Island OXFAM office;
- Examined development projects in Sudan and in the war zone of Eritrea, Africa as part of a fact-finding tour;
- Coordinated visits to Vancouver Island of overseas partners to promote understanding of international development issues.

EDUCATION

Bachelor of Arts (with distinction), Political Science and History, University of Victoria, 1985.

Janet M. Stavinga
67 Randall James Drive
Stittsville, Ontario K2S 1M4
Tel: 613-836-1125 Fax: 613-836-2523
E-mail: stavinga@compmore.net

_To:_	**_Neill Thompson_** **_Indian and Northern Affairs_** **_Yellowknife, N.W.T._**	**_Fax:_** **_Tel:_**	**_403-669-2716_** **_403-669-2659_**
From:	**_Janet Stavinga_**	**_Fax:_**	**_613-836-2523_**
Subject:	**_Work Experience_**		
Date:	**_September 17, 1997_**		
Total Pages:	**_4_**		

Dear Neill:

Heard through Don MacDonald that you requested information on my work experience. Please find this information enclosed. Do not hesitate to contact me, should you require any further information. Looking forward to keeping in contact with you. Hope you are keeping well.

Kindest regards,

Janet S.

JANET M. STAVINGA
67 Randall James Drive
Stittsville, Ontario K2S 1M4
Tel: 613-836-1125 Fax: 613-836-2523
e-mail: stavinga@compmore.net

Janet Stavinga has had extensive facilitator training through the Institute of Cultural Affairs - Canada in Group Facilitation, Facilitated Planning, Working with Social Change and Team Leadership. Ms. Stavinga possess a Master of Science in Geography through McGill University, and an Honours Bachelor of Arts in Resource Management from the University of Windsor.

In addition to the above training and education, Ms. Stavinga has considerable experience in integrating community involvement and values into ecosystem management systems. Ms. Stavinga is an effective communicator and facilitator with extensive experience in scientific and multi-stakeholder forums with government, industry, and community representatives. This expertise has been developed in part through the following activities:

- Workshop facilitator in association with MacDonald Environmental Sciences Limited for the **Workshop on Controlling Arsenic Releases in the N.W.T.** held in Yellowknife, N.W.T. in July 1997 convened under a multi-agency Task Force comprised of Environment Canada, Health Canada, and GNWT Health and Social Services.

- Workshop facilitator in association with the Canadian Institute of Cultural Affairs for a workshop on **Moving Towards Sustainable Production and Consumption: Building a Community Of Concern and Commitment** held in Aylmer, Quebec in May 1997 sponsored by the National Office of Pollution Prevention, Environment Canada.

- Workshop facilitator in association with MacDonald Environmental Sciences Limited for a workshop on **Selecting Indicators for a Sustainable Watershed Future** held in Falkland, B.C. in March 1997. This workshop was convened by the Environmental Conservation Branch, Environment Canada - Pacific and Yukon Region in conjunction with the Salmon River Watershed Roundtable. This was the third phase in the pilot project under the auspices of the Canadian Council of Ministers of the Environment (CCME) National *Framework for Developing Ecosystem Health Goals, Objectives and Indicators: Tools for Ecosystem-Based Management.*

- Workshop facilitator and advisory services in the creation of a public participatory process in conjunction with the **Rideau Valley Conservation Authority** to engage the community in a series of workshops held in January and February 1997 to develop ecosystem health goals and objectives for the Jock River Watershed.

Continues

- Workshop facilitator for the **Workshop on the Management of Federal Contaminated Sites** held in Ottawa, Ontario in October 1996 convened under the auspices of the Federal Interdepartmental Committee on Contaminated Sites. This two day workshop involved the presentation of scientific assessment and management tools for contaminated sites developed by the Guidelines Division, Environment Canada under the auspices of the CCME.

- Working Group Facilitator and advisory services to the **Sustainable Fisheries Foundation** for multi-disciplinary conferences held in Victoria, British Columbia in April 1996 and in Seattle, Washington in September 1996. This included coordinating the development of the methodology that was utilized by work group facilitators in the various concurrent workshops.

- Coordinating the development of a Compendium of Indicators of Ecosystem Health Goals, Objectives and Indicators on behalf of the **Science Policy and Environmental Quality Branch (SPEQB) of Environment Canada**, in collaboration with other Environment Canada branches and federal agencies. The Compendium and associated Quick Reference Guides are tools to assist communities interested in developing ecosystem management plans and strategies, by providing a quick reference to ecosystem health goals, objectives and indicators developed through participatory multi-stakeholder processes. The compendium has been compiled as a means to share the knowledge of community ecosystem health initiatives being undertaken in Canada.

- Advisory services to **Environment Canada/Pacific and Yukon Region, SPEQB, British Columbia Ecosystem Objectives Steering Committee and the Salmon River Watershed Roundtable** in a pilot project under the auspices of the CCME National *Framework for Developing Ecosystem Health Goals, Objectives and Indicators: Tools for Ecosystem-Based Management* to integrate ecological, economic and community goals and values into ecosystem planning and management activities.

- Working Group Facilitator for the **Canadian Wildlife Service, Environment Canada** for the National Workshop on the *Canadian Endangered Species Protection Act: A Legislative Proposal* held in Ottawa, Ontario in May 1995 and Hull, Quebec in December 1995.

- Coordinated training workshops for representatives of the Ecosystem Flagship Initiatives entitled *"Working in Multi-stakeholder Processes"* for the **Evaluation and Interpretation Branch, Environment Canada** and in collaboration with the Pacific & Yukon and Ontario Regions and The Great Lakes Pollution Prevention Centre held in Vancouver B.C. and Hamilton, Ontario in September 1994.

- Co-organized with the **Evaluation and Interpretation Branch, Environment Canada** a pre-symposium workshop entitled *"Incorporating Societal Values in Ecosystem Health Objectives: Addressing the Challenge"* held in conjunction with the *1st International Symposium on Ecosystem Health and Medicine* held in June 1994.

Continues

- Currently, a Municipal Councillor for the **Township of Goulbourn, Ontario** (population 20,000) establishing policy direction within a municipal environment on a variety of issues including community development strategies for land use planning, economic development, environmental stewardship, financial priorities, public transportation, and recreational activities while actively fostering citizen involvement in the various initiatives of local government. Council appointed responsibilities include serving as Chair for the Finance Committee, and Council representative to specific citizen advisory committees.

- Council lead in the development and implementation of a methodology to engage the youth in Stittsville, a village in the **Township of Goulbourn, Ontario**, in a community facilitated planning process based upon consensus. Over 400 youth from six to fifteen years of age participated in planning sessions to define a vision for the community.

- Spokesperson for a community based organization, **Citizens for Sensible Planning** formed in December 1993 to pursue land use management plans which are consistent with the goals of the community and incorporate important social, economic and environmental considerations. Over 850 residents with the Township of Goulbourn confirmed their support for the efforts of this organization.

- Technical Advisor to the **Environmental Choice Program (ECP), Environment Canada** from 1992 to 1994. Evaluation of technical and scientific information on the environmental impacts related to product/service categories for which guidelines are being developed, and the range of criteria that might be used to limit or mitigate these impacts. Coordinated activities in support of guideline development including the organization of Review Committees, public review process, approvals and announcement of final guidelines, and the provision of secretariat functions to the ECP Advisory Board.

EDUCATION

Group Facilitation, Facilitated Planning, Working with Social Change, Team Leadership
Institute of Cultural Affairs - Canada, 1996
Master of Science, Geography, Water and Sediment Chemistry, McGill University, 1991
Bachelor of Arts (Honours), Geography, Resource Management, University of Windsor, 1986

AWARDS

Natural Sciences and Engineering Research Council of Canada
Postgraduate Scholarship 1986-88
Indian and Northern Affairs Northern Training Research Grant 1985, 1987
Association of Canadian Universities of Northern Studies, Northern Studies Trust Fund 1986-87
Canadian Water Resources Association Undergraduate Scholarship 1986
University of Windsor, Board of Governor Medallist 1986
Natural Sciences and Engineering Research Council of Canada Undergraduate Scholarship 1985

Government of Canada Gouvernement du Canada

MEMORANDUM NOTE DE SERVICE

TO / A: Water Resources Division
Environmental Screening Committee

Security Classification de sécurité

Our file - Notre référence: N3-1-1699

Your - Votre référence: File

FROM / DE: Mr. Jim McCaul
Head, Regulatory Approvals
Water Resources Division
3rd Floor, Bellanca Building

Date: September 18,1997

SUBJECT/OBJET:

GOVERNMENT OF THE NORTHWEST TERRITORIES - WINTER ROAD BRIDGE CONSTRUCTION VERMILLION CREEK, MACKENZIE HIGHWAY WINTER ROAD, KM. 984.4
LEVEL 1 - INITIAL ENVIRONMENTAL ASSESSMENT AND SCREENING (TYPE B LICENCE)

As a federal responsible authority, Indian and Northern Affairs Canada is required to conduct an environmental assessment and screening of the above project in accordance with Section 5 of the Canadian Environmental Assessment Act. This activity is being initiated concurrently with the technical review of the application for licence renewal. Regardless of the timing, environmental and technical reviews are being conducted separately.

Would you please review the enclosed water licence application and supporting documentation and provide your comments and advice regarding any environmental concerns that you wish this department to take into account in making its screening decision. If no response is received by the due date, we will assume that you have no specific concerns, and that the licence application may proceed through the regulatory process.

Your input should be received in this office on or before **October 17, 1997.**

Please note that this application meets the criteria for a "Type B" licence, and NWT Water Board will not be scheduling a public hearing. As such, please ensure that your environmental concerns and recommendations are forwarded to us for consideration.

Should you have any questions, or if additional information is required, please contact Greg Cook at (403) 660-2656, or Brian Collins at 669-2657. Our fax number is (403) 669-2716. Thank you.

Jim McCaul (669-2653)

c.c. Greg Cook/Brian Collins/Sevn Bohnet, Water Resources Division
B. Latham

Distribution

Inuvik District (local consultation)
Environment & Conservation Division
J. Dahl, DFO
S. Harbicht, EP/DOE

T.A.C. Memo

Northwest Territories Water Board
Technical Advisory Committee

September 18, 1997

To: Distribution

File: TAC General
N3-8-1699

From: Jim McCaul
Head,
Regulatory Approvals Section

Subject: **Government of the Northwest Territories - Winter Road Bridge Construction**
Vermillion Creek, Mackenzie Highway Winter Road, Km 984.4

Enclosed are the relevant documents required to perform a Technical Review for the above mentioned licence application for winter road bridge construction. Would you please review the enclosed water licence application and provide technical comments that should be considered for licence development.

Please provide any comments that you have on or by October 17, 1997.

If no response is received by the due date, we will assume that you have no concerns.

If you have any questions or concerns, please call me at (403) 669-2653, or Brian Collins, Project Coordinator at (403) 669-2657.

J. McCaul (403-669-2653) (fax-669-2716)
(e-mail "mccaulj@inac.gc.ca")

cc: D. Milburn
B. Latham
B. Collins, S. Bohnet, G. Cook
Inuvik District

Distribution List

- L. Dyer - GNWT/RWED
- S. Bradbury - Land Administration
- J. Dahl - DFO
- S. Harbicht - EP
- F. Hamilton - GNWT/Health
- G. Barnaby - Sahtu Dene Council
- B. Williams - GNWT/MACA
- A. Shevkenek - MACA - Community Development