YUKON PASSIVE WATER TREATMENT WORKSHOP

JUNE 3-4, 2014

EVENT SUMMARY REPORT

Submitted to the Workshop participants

Yukon Mine Research Consortium

Amelie Janin, Yukon College, ajanin@yukoncollege.yk.ca, (867) 668-8881

Martin Haefele, Capstone Mining Corp., mhaefele@capstonemining.com, (604) 424-8379

Yukon Environnent

Bob Truelson, Yukon Environnent, Bob.Truelson@gov.yk.ca, (867) 667-3217

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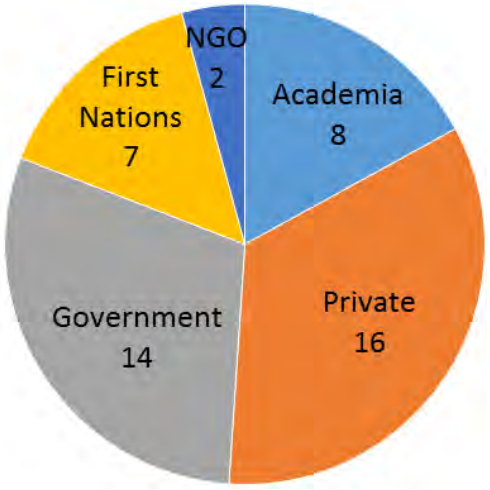
1. EXECUTIVE SUMMARY

The goal of Yukon Passive Water Treatment Workshop was to foster discussions between mines environmental personnel, regulators, project managers, consultants, design engineers, and other affected stakeholders to identify the gaps that need to be addressed. The specific objectives were:

1. Facilitate communication between stakeholders and set up an environment for constructive discussion on progressing passive water treatment systems in the Yukon.
2. Identify constraints, gaps, and reservations that industry, regulators, and researchers encounter.
3. Increase knowledge-sharing
4. Encourage the development of plans on how to address these issues.

This event was planned and organized by Amelie Janin, NSERC Industrial Research Chair at Yukon College, Bob Truelson, Manager, Water Quality Section with Environment Yukon, and Martin Haefele, Permitting Manager at Capstone Mining Corp. Forty-seven participants attended the workshop, representing the various stakeholders.



The workshop helped to successfully bring out a few themes that presented themselves through question periods and group facilitation. There was agreement that many stakeholders have common goals and effective collaboration and resource pooling will help to better meet these goals. It was generally agreed that further research is needed to further tailor passive treatment technologies for application in Yukon. The creation of a group supporting the development of passive water treatment was suggested by the participants, possibly using the Mine Environment Neutral Drainage (MEND) model.

It was also identified that the decision-making process in long-term treatment plans should include First Nations Government in advisement and monitoring, lower the dependency on prescribed technological terms, but rather emphasize the technology's process and targets.

Overall, this event successfully met many of its goals and it is noteworthy there was a 100% survey respondent consensus that the workshop changed the way participants will conduct future work regarding passive water treatment technologies.

2. BACKGROUND

Alexco Resources Corp., Capstone Mining Corp, Victoria Gold Corp. and Yukon Zinc formed the Yukon Mine Research Consortium in 2011, which led to the establishment of Amelie Janin as the NSERC Industrial Research Chair Program at Yukon College, aiming at advancing research on cold climate environmental remediation technologies.

Sharing a common goal of communicating practical, remedial solutions for mining in the north, Amelie Janin (Yukon College), Bob Truelson (Yukon Environment) and Martin Haefele (Capstone Mining) collaborated to bring this workshop to Whitehorse, YT. The two-day workshop was held at Yukon College on June 3-4th 2014, using $7,000 funding from the federal government (NSERC) and a registration fee to cover costs.

The event format, speakers and participant lists were put together by the three organizers. Workshop participation was by invitation and attendance was capped to allow for meaningful discussion amongst the stakeholders. The organizers found that interest in the workshop topic areas was strong.

3. WORKSHOP PROGRAM

The event program is attached as Appendix 2.

Day 1 of the workshop was a short course presented by Dr. James Higgins of Environmental Technologies Development Corporation. The course ran from 8:30 am until 4:30 pm and consisted of four presentation modules that included the following modules:

- The Treatment of Mining Influenced Waters
- Engineered Bioreactors for Semi-Passive MIW Treatment
- The Chemistry and Microbiology of MIW Treatment in Bioreactors
- The Design and Construction of Aerobic and Anaerobic Bioreactor-Based Engineered Bioreactor Systems

Day 2 of the workshop consisted of five presentations by speakers from various backgrounds and industry who are involved in some manner with bio-treatment of mine water in the Territory:

- “Anaerobic reactor trials at the Keno Hill District, YT” by Jim Harrington, President of Alexco Environmental Group
- “Wetlands design for operation at Minto Mine, YT” by Dr. Monique Haakensen, President and founder of Contango Strategies and Adjunct Professor at the University of Saskatchewan
- “Genomics: How can this tool be used for better characterization of biological water treatment” by Dr. Susan Baldwin, Professor at the University of British Columbia
- “Experience with biological treatment at Yukon’s abandoned mines” by Frank Patch, Senior Project Manager, AAM Branch, EMR, Yukon Government

- "Yukon College's research initiatives to support local mining industry" by Dr. Amelie Janin, NSERC Industrial Research Chair at Yukon College

All presentations and relevant documents can be found in Appendix 2.

A tour of the Yukon Research Center Lab was given by Amelie Janin, and included the analytical lab and pilot-scale equipment on passive water treatment technologies in the facility.

In the afternoon, Martin Haefele facilitated the Group Session, aimed at determining the next steps required to support development of passive treatment for mine impacted waters in Yukon.

To conclude, a survey was completed by participants.

4. WORKSHOP MATERIALS

A 'Dropbox' folder entitled "Yukon Passive Water Treatment Workshop Docs" contains relevant workshop materials with which references have been shared with the participants. It includes:

- Short course handouts (modules 1 to 4 and wrap-up)
- All Day 2 speakers presentations
- The new Reference Guide to Treatment Technologies for Mining-Influenced Water from USEPA (March 2014)
- Bibliography and glossary for the short course

5. SOME PRESENTATION KEY MESSAGES

Key messages from the speakers included the following:

- Future treatment technologies should be less focused on active treatment during operations, and more on the complete mining life cycle, including post-closure
- Most passive and semi-passive treatment systems require maintenance for several years and will require some level of monitoring as well
- Ongoing collaboration with First Nations, regulators, and other affected stakeholders will support monitoring quality and consistency
- To sequester contaminants in constructed wetland systems, mineralization must occur to achieve stability

- Sulfate, in the last couple of years, has proven to mobilize harmful metals such as mercury (Hg). This has led to limitations on use of sulfate in British Columbia and will most likely become a part of regular policy in most areas.
- An example of the potential for manipulating bioreactor systems can be shown in the relationship between redox potential and dissolved oxygen (DO) with populations of Sulfate Reducing Bacteria (SRBs) versus Methanogens

6. DEVELOPMENT OF PASSIVE TREATMENT - PERSPECTIVES FROM PARTICIPANTS

6.1. Current challenges

- Terminology: It has been identified that many treatment technologies can have several terms attached to it. Practitioners have had concerns with the misuse of terms that can cause confusion.
- Site access: access to mine sites is limited for safety reasons although that restricts research developments
- There is a high bar for passive treatment, although closure policies tend to prohibit active treatment.
- Bioaccumulation of metals in wetland vegetation: Might poses a problem for Constructed Wetlands (CWs) and should be mitigated by maximizing sub-surface sequestration and minimizing uptake of metals in the above ground biomass
- A database for northern plants that can be used for bio-remediation is not readily available

6.1.1. Industry-Specific Challenges

- Amount of information needed to achieve regulatory approval is not clear
- Keeping knowledge proprietary stems from the concern of assuming liability for any technological development
- Collaborating more effectively to facilitate the necessary oversight during post-closure s would be beneficial to the government as they assume liability and costs of closure if the mine does not have the resources to do so
- Public support: Low
- Mine operations demand a high level of safety and control. It is difficult to operate a pilot project, much less to invite a third party within an operating mine

6.1.2. Government-Specific Challenges

- Risk-averse approach: due to the potential liability they take on (precautionary principle)
- Many local examples of companies not having comprehensive closure plans/funding, and after abandonment, care and maintenance operations having to be assumed by government
- Reliance on unproven technologies is difficult for assessors to approve

6.2. Future Prospects

- Technology development: Need to prove systems work in Yukon. Available literature such as that of James Gusek's can be further customized for Northern areas to give a better starting off point.
- Research: Academic researchers should maintain applicability of their research and practicality for the industry.
- Climate change: Study impacts of cold climates on technology, adapt to climate change, manage permafrost scenarios, include detailed plans for freshet management/handling
- Training: Local individuals should be able to get appropriate training to build/operate/monitor these new technologies.
- First Nations: Must be involved in the decision-making process and monitoring of passive treatments, especially with constructed wetlands as many bog plants are used for medicinal and cultural purposes
- Increase knowledge transfer between various stakeholders and foster better communication by minimizing jargon
- Pool resources to meet common goals
- Terminology: Finding a common terminology for different water treatment technologies is an issue that needs to be addressed for regulators to understand how technologies differentiate.
- Creating a system of classification for technological terms is another possible solution that have been attempted by introduction of the Global Acid Rock Drainage Guide (GARD)

6.2.1. Industry-Specific

- Understand regulator risk tolerance and develop adaptive management based on data/well characterized site conditions
- Finances: Structure financial bonds for remediation upon mine closure in application
- Design: Include detailed closure planning up front, contingency planning for unexpected events, and source control
- Access: Allow better access by 3rd party individuals including pilot projects
- Communication: Maintain effective communication with researchers to ensure end goals are being met

6.2.2. Government-Specific

- Consistency: Increase common understanding/acceptance about passive water treatment among regulating bodies (e.g., YWB, EMR, ENV)
- Acceptance: Help increase public acceptance about proven technologies
- Research: Help fund research that is needed in this sector to improve the level of acceptance
- Risk assessment: Exploring models that have a more “holistic” approach to risk assessment and depend less on “pass/fail” requirements holds promise for approaching the risk-adverse nature of regulation.
- Encourage knowledge-sharing by helping protect industry when proprietary information is shared

6.2.3. Academia-Specific

- Applicability: Ensure and maintain applicability and practical scalability of research projects
- Research planning: Keep end goals and main purpose of research in mind
- Database: Work to create database with research and encourage knowledge-sharing
- Communication: Minimize jargon to ensure effective communication with various stakeholders

6.2.4. First Nations-Specific

- Decision-making: Work to become part of the decision-making process and long-term monitoring of treatment technologies
- Communication: Effectively communicate questions and concerns and take part in the solutions
- Help in pooling resources to meet common goals

6.3. Next actions

- New group: Forming or joining an existing multi-stakeholder group to "hold" the information and push issue forward will grow local capacity, encourage the utilization of traditional knowledge, help ensure funding for effective communication, prioritize and focus efforts, and advocate non-prescriptive/outcome-based regulatory guidance principles. This Yukon-based Secretariat can be inspired by models such as the MEND model.
- Yukon-specific discussion: Continue to hold similar workshop/group discussion on a yearly basis.
- Communicate passive water treatment initiatives: Collaboration with the Yukon Chamber of Mines could possibly help with sharing information. Could we establish a session on Passive Water Treatments at Geoscience every November?
- Database: Information on the development of passive water treatment technologies could be centralized for easier access and consultation

6.3.1. Industry-Specific

- Restructure mine site protocol to allow better access by 3rd party individuals and pilot projects
- Adapt protocol that will encourage knowledge sharing
- Help academia secure research funding

6.3.2. Government-Specific

- Do more to endorse good mining practices
- Set up a database for knowledge-sharing
- Clearly specify amount of information needed for technology to be proven

6.3.3. Academia-Specific

- Develop training courses at Yukon College for treatment technology monitoring and development
- Develop research projects that will help test new technologies
- Collaborate with industry and governments to ensure that research projects have applicable goals and objectives
- Help industry and government secure research funding

6.3.4. First Nations -Specific

- Add to knowledge-sharing database
- Share traditional knowledge that will help design appropriate remediation technologies

7. WORKSHOP APPRECIATION & RECOMMANDATIONS

The workshop received mostly positive responses from participants. An evaluation form was distributed to attendees on the afternoon of day 2, during the group session. Twenty-two surveys were returned and compiled:

Workshop goal:

The surveyed participants were asked if this workshop would change the way individuals conduct business for the future: 100% of respondents wrote “yes”, indicating a very successful outcome of this workshop. Identifying challenges and constraints in passive water treatment technology and coming up with solutions will ensure that development of bioremediation in Yukon continues and will influence other northern regions.

Themes from Survey:

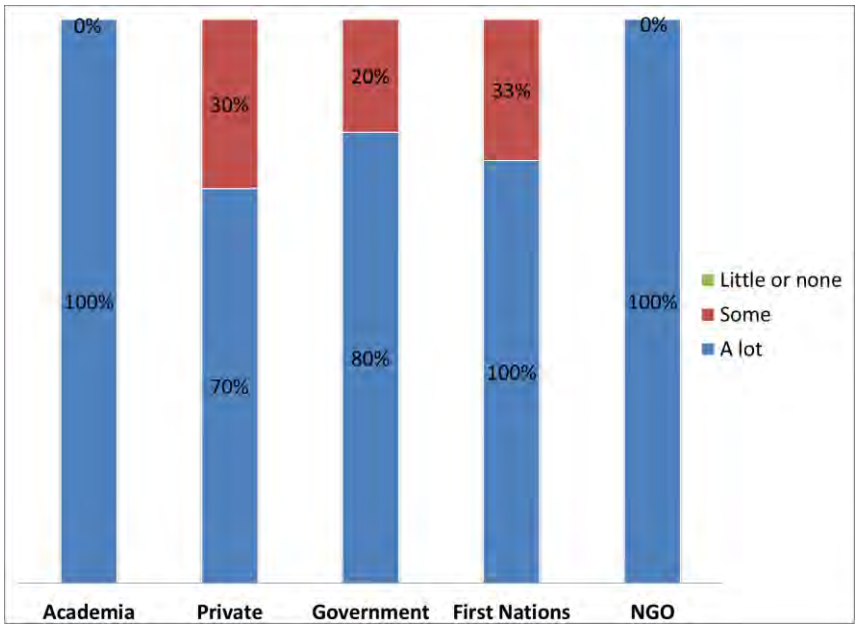
- Greater focus on specific treatment technologies and in northern climates
- Very positive response for Day 2 format about Yukon case histories and the facilitated group session: many believed it led to very successful discussions
- The short course was too technical at times and not always applicable to northern regions

Workshop format:

It is challenging to have a specific, technical focus for a workshop reach a diverse group of participants. In an effort to introduce people to bioremediation the short course on passive water treatment preceded the Yukon case studies. This may have been at the expense of those who were already very knowledgeable in this area, or conversely was too detailed for those without enough technical background to grasp the concepts in the course. To gain an idea of how individuals felt about information given in the workshop, to assist future event planning, attendees were asked to rank how much they felt they learned. Most respondents indicated that they learned a lot and 0% of survey completers indicated that they learned "little-to-nothing" (Fig 2)

- Most attendees were able to attend both days of the workshop. Indicating the workshop was an appropriate length.

Attendee Response to Learning Achievement



Recommendations for future event:

There was considerable interest in the creation of a committee that will hold annual workshops on passive water treatment. Participants suggested more interaction should take place between various stakeholders to continue to develop the technology in Yukon and to create a clearing house for information and lessons learned. The presentation on Yukon initiatives was considered to be a highlight of the workshop and it was thought that this format should continue and will foster better communication overall. The organizers also felt that the group session was highly productive in terms of engagement and involvement of the participants; numerous suggestions were brought forward to support the furtherance of passive water treatment in Yukon.

APPENDIX 1 – PARTICIPANT LIST

Table 1: List of attendees

Name	Organization
Trevor "Scott" Keesey	Access Consulting Group
Jim Harington	Alexco Environmental Group
Martin Haefele	Capstone Mining Corp
Mary Mioska	Casino Mining Corp
Andre Sobolewski	Clear Coast Consulting
Monique Haakensen	Contango/University of Saskatchewan
Caleb Light	EDI Dynamics
Jim Higgins	ETDC
Michael Muller	Hemmera
Guillaume Nielsen	INRS ETE/Yukon College
James Scott	Kaminak Gold Corp
Bonnie Burns	Laberge Environmental
Ken Nordin	Laberge Environmental
Frank Patterson	Nacho Nyak Dun First Nations
Josee Tremblay	Nacho Nyak Dun First Nations
Ray Sabo	Nacho Nyak Dun First Nations
Cord Hamilton	Selkirk First Nations
David Silas	Selkirk First Nations
Dean Gill	Selkirk First Nations
George Magrum	Selkirk First Nations
Jillian Chown	Selwyn Chihong Canada Mining Ltd
Cameron Sinclair	Stantec
Nicole Jacques	Summit Environmental
Stephan Klump	TetraTech EBA
Sue Baldwin	University of British Columbia
Steve Wilbur	Victoria Gold Corp
Nathan Aasman	YESAB
Alissa Sampson	YG Energy, Mines, and Resources
Briar Young	YG Energy, Mines, and Resources
Dustin Rainey	YG Energy, Mines, and Resources
Erin Dowd	YG Energy, Mines, and Resources
Frank Patch	YG Energy, Mines, and Resources
Julie Houle	YG Energy, Mines, and Resources
Bob Truelson	YG Environment
Jean Beckerton	YG Environment
John Minder	YG Environment
Julia Ahlgren	YG Environment
Richard Cherepak	YG Environment
Amelie Janin	Yukon College
Katherine Stewart	Yukon College
Mary Samolczyk	Yukon College
Michel Duteau	Yukon College
Sabrina Clarke	Yukon College
Lewis Rifkind	Yukon Conservation Society
Darryl Cann	Yukon Water Board
Jennifer Logan	Yukon Water Board
Neil Salvin	Yukon Water Board
Andrea Kenward	Yukon Zinc Corp

APPENDIX 2 – PROGRAM

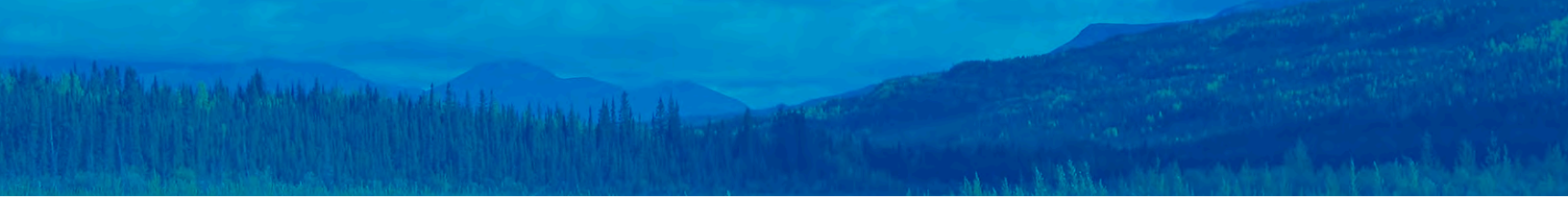
The Yukon Mine Research Consortium
and Yukon Environment invite you to:

YUKON PASSIVE WATER TREATMENT WORKSHOP

JUNE 3-4 2014 **AT**
YUKON COLLEGE **(ROOM T1023)**
Registration fees: $360 *

The event is sponsored by

*** Please confirm attendance before May 16th 2014.**



Workshop goal and objectives

The goal of this event is to foster discussions between industry, regulators and researchers and identify the gaps that need to be addressed to support development of passive water treatment in Yukon. The workshop will offer an opportunity for mine reclamation practitioners and land/water managers to learn about passive water treatment with a focus on biological treatment. This event will highlight Yukon case studies and identify strategic initiatives that will further support the development of passive mine water treatment in the territory.

Who should attend?

Mining Environmental Personnel, Regulators, Project Managers, Consultants, Design Engineers, Wastewater Treatment Specialists, University & College Staff & Students.

Day 1 - Short course

By **Dr. James Higgins ***, Environmental Technologies Development Corporation

Passive Treatment Technologies for Minewaters

- Passive Treatment Technologies for Minewaters
- The Use of Wetlands for Minewater Treatment
- Aerobic & Anaerobic Bioreactors for Minewater Treatment
- Cyanide chemistry and biological closure of heap leach pad
- Nitrate, Sulphate & Iron Reduction in Bioreactors
- The Use of Permeable Reactive Barriers (PRBs) in Minewater Treatment
- The Use of Constructed & Engineered Wetlands in Minewater Treatment
- Minewater Management after Closure

*** See page 3 for a short bio of Dr. Higgins.**

Day 2 - Yukon Case Studies

8:00-8:30	Breakfast
8:30-9:15	"**Anaerobic reactor trials at the Keno Hill District, YT**" by **Jim Harrington**, President of Alexco Environmental Group
9:15-10:00	"**Wetlands design for operation at Minto Mine, YT**" by **Dr. Haakensen**, President and founder of Contango Strategies and Adjunct Professor at the University of Saskatchewan;
10:00-10:15	Coffee break
10:15-11:00	"**Genomics: How can this tool be used for better characterization of biological water treatment**" by **Dr. Baldwin**, Professor at the University of British Columbia
11:00-11:45	"**Experience with biological treatment at Yukon's abandoned mines**" by **Frank Patch**, Senior Project Manager, AAM Branch, EMR, Yukon Government
11:45-12:00	"**Yukon College's research initiatives to support local mining industry**" by **Dr. Janin**, NSERC Industrial Research Chair at Yukon College
12:00	Visits of Yukon College's research laboratory facilities by **Dr. Janin** (in two groups, 20 min each)
12:00-1:15	Lunch break
1:15-3:15	**GROUP SESSION**: "**What are the next steps required to support development of passive treatment for mine-impacted waters in Yukon**" facilitated by **Mr. Haefele**, Permitting Manager Capstone Mining Corp
3:15-3:30	**Closing comments** by **Robert Truelson**, Manager, Water Quality Section, Yukon Government

Short course instructor:

Dr. James Higgins

Dr. Higgins has been the Project Director/Project Executive/Technical Manager/Qualified Person for a variety of mining and environment projects in operating and mines in several provinces including Yukon. He has been involved in the preparation of closure plans, PEAs, applications for permits and licenses for new and re-activated mines, and in the design and engineering of active and passive wastewater treatment systems for all sorts of mine waters, including the most recalcitrant ones. He led the team for the design, engineering and commissioning of the now-successfully-operating treatment system at Buffalo Niagara International Airport which includes four large Bioreactor Engineered Wetlands (BREW Bioreactors), each as large as a football field. The team was awarded an Honor Award in 2010 by the American Association of Engineering Companies for this project. Dr. Higgins has been an Adjunct Professor and a Lecturer in chemical engineering at the Universities of Ottawa and Toronto, and is currently an Adjunct Professor in the School of Environmental Science at the University of Guelph. He has taught numerous short courses on subject areas such as the natural & active wastewater treatment of minewaters, wetlands engineering, site reclamation, phytoremediation, minewater metals and metalloids management (e.g., As, Cr), and ecological engineering. He has been an active member of several mining related committees including the Ontario Mining Association's Environment Committee. Jim Higgins was involved with short courses on minewater treatment areas at conferences such the ICARD 2006, Sudbury 2007 and CIM 2013. Dr. Higgins recently retired from Stantec but continues to manage R&D and development projects for that firm.

Workshop organizers:

Dr. Amelie Janin, Industrial Research Chair, Yukon College

Amelie Janin specialized in metals chemistry and environmental remediation during her PhD in Water Sciences at the National Institute for Scientific Research (INRS) in Quebec City and during her following experience at the University of Toronto where she coordinated an applied research project with Hydro-Quebec. Living in Yukon since 2011, Dr. Janin now holds the NSERC Industrial Research Chair at Yukon College since January 2013. Through this program entitled "Mine Life Cycle", Amelie is collaborating with Alexco Resource, Capstone Mining, Victoria Gold and Yukon Zinc to advance research on cold climate environmental remediation technologies.

Bob Truelson, Manager, Water Quality Section, Yukon Government

Robert (Bob) Truelson, B. Sc., is a graduate of UBC and has accumulated 35 years of work experience with water resources departments in B.C. and Yukon. He has served as the Yukon representative on the CCME Water Quality Task Group for the past 11 years. Bob is presently Manager, Water Quality Section of Yukon Environment and involved with the regulation of water licenses through all sectors of water use and wastewater discharges. His current activities include managing a water quality trend monitoring network across key sites in the territory and he maintains a keen interest in development of new aquatic health assessment tools and emerging science in genomics and biotechnology.

Martin Haefele, Permitting Manager, Capstone Mining Corp.

Martin's interest in bioremediation goes back to his student days when he worked on contaminated sites for an environmental NGO in his native Germany. After a stint in academia his professional path veered off into the field of impact assessment and project licensing. For the past 15 years he has been involved in assessing projects ranging from mineral exploration to infrastructure, to oil and gas developments and mining. Virtually all of it in the Northwest Territories and Yukon. Along the way he picked up experience in organizing and facilitating community meetings, public hearings, workshops and conferences. Currently he is Capstone Mining Corp's permitting manager for the Minto Mine.

Workshop speakers:

Jim Harrington, President, Alexco Environmental Group

Mr. James Harrington, Jim, MSc, has been the President of Alexco Environmental Group at Alexco Resource Corporation since January 2010. Mr. Harrington served as Vice President of Engineering - Alexco Resources U S Corp. of Alexco Resource Corporation since February 2007. Mr. Harrington, whose technical expertise is focused on groundwater related remedial technologies and water treatment, has worked for the Alexco Environmental Group since 2007 as Vice President of Engineering ... and Technical Services. Previously, He served as Vice President in the corporate technical group at ARCADIS G&M and Vice President of mine remediation and closure at Shepherd Miller. He holds an MSc in Microbiology and Biochemistry.

Dr. Monique Haakensen, President and founder of Contango Strategies; Adjunct Professor, University of Saskatchewan

Dr. Monique Haakensen is the President and Principal Scientist of Contango Strategies which she founded in 2010 and has grown into a thriving environmental firm with laboratories and dedicated constructed wetland pilot facilities serving North America and Europe. As a result, she has been named one of Canada's future entrepreneurial leader's by Profit Magazine. Monique sits on a number of boards and committees, and serves as an Adjunct Professor at the University of Saskatchewan, lecturing and assisting in the supervision of students in the Toxicology, Bioresources, and Bioinformatics departments. Monique previously served as an Academic lead for the University Arctic. In 2014, Dr. Haakensen became the youngest person ever appointed to Canada's Science, Technology and Innovation Council, providing the federal government with confidential, evidence-based advice on key issues that affect Canadian society and our economic development.

Dr. Sue Baldwin, Professor, University of British Columbia

Dr. Susan Baldwin is an associate professor at UBC in the Department of Chemical and Biological Engineering and is currently studying the use of microbial communities in the bioremediation of mine drainage. She holds a doctorate from the University of Toronto in Biomedical Engineering and an MSc in Mechanical Engineering from the University of Cape Town, South Africa. Dr. Baldwin completed her postdoctoral training at McGill University in Montreal in the modeling of hydrometallurgical reactors and at Delft University of Technology in the Netherlands in hydrometallurgy with a focus on iron oxidation.

Frank Patch, Senior Project Manager, AAM Branch, EMR, Yukon Government

Frank Patch B.Sc., has worked in Yukon since 2001 as a Water Inspector for DIAND Water Resources, as an Environmental Assessment Analyst for YG Environment, and as a Senior Project Manager for YG Assessment and Abandoned Mines Branch. He has experience with the regulatory approval of mine development, water licence enforcement, and environmental protection and development of closure plans for abandoned mines.