Air Sparging and Soil Vapour Extraction Systems for the Remediation of Volatile Organic Compounds in Groundwater and Soil Vapour: A Contractor's Perspective

Nishil Mohammed and Jesse Hutton, Green Infrastructure Partners Inc.

The presence of volatile organic compounds (VOCs) in groundwater and soil vapour poses a significant threat to public health and the environment. Air sparging and soil vapour extraction (AS/SVE) are two commonly used techniques for the remediation of VOCs in groundwater and soil vapour.

Previous environmental site investigations completed at a confidential site in Ontario identified that VOCs, more specifically trichloroethylene (TCE), are present in groundwater and soil vapour at concentrations exceeding applicable groundwater standards and residential vapour intrusion criteria, respectively. The AS/SVE technique was selected as a remediation technique after a successful pilot-scale study, and a full-scale system is currently being operated on-site as part of the remediation program. Green Infrastructure Partners Inc. (GIP) was contracted to assist with both the pilot-scale and full-scale scope of the project.

The AS/SVE system was designed to remove VOCs from groundwater and soil vapour by injecting air into the contaminant zone, which promotes the release of VOCs into the soil vapour phase. The VOCs are then extracted from the soil vapour phase by a vacuum system installed in a series of wells. The extracted VOCs are simultaneously treated using air phase carbon filtration, and the removal of VOCs was monitored during the system operation. Additionally, the system showed a high degree of reliability and was able to operate continuously without any significant downtime.

This presentation will provide a contractor's perspective on the mobilization, setup, installation, commissioning, and operation of the AS/SVE system and why a system like this is a viable option for the remediation of contaminated sites and should be considered as part of any remediation strategy for sites contaminated with VOCs.

Nishil Mohammed

Dr. Nishil Mohammed, Ph.D., is currently working as a project manager with the Remediation Technologies Group at Green Infrastructure Partners, Inc., where he manages water, soil, and air remediation projects across Ontario, Canada. He has experience working with environmental consulting, contracting, and R&D organizations in Canada, the United States, and India. He is experienced in the design, build, and operation of decentralized and mobile treatment systems for environmental remediation and dewatering projects. Most of his work has been problem-solving to achieve the treatment goals for in-situ and ex-situ remediation projects using advanced knowledge obtained from laboratory, bench-scale, and pilot-scale treatability testing studies. He obtained his doctoral degree in chemical engineering from the University of Waterloo and is also the author of more than 10 publications in peer-reviewed scientific journals.

Remediation and Risk Management Strategies for Managing an LNAPL Impacted Site

Sam Caldwell, Stantec Consulting Ltd.

The Kraut Point site is a Small Craft Harbour (SCH) managed by Fisheries and Oceans Canada (DFO) located in Riverport, Nova Scotia. The site has been a commercially active fishing wharf for over 100 years and is currently home to approximately 15 – 20 fishing vessels. A historic fuel oil spill had resulted in the presence of a large LNAPL body and dissolved-phase PHC plume at the site adjacent to the marine environment. As this is a federal contaminated site, the Federal Contaminated Sites Action Plan (FCSAP) 10-step decision making framework (DMF) has been applied to manage the environmental impacts at the Site. A series of investigations have been completed at the Site to date, including Phase I, II, and III environmental site assessments (ESA), annual groundwater monitoring, a laser-induced fluorescence program, and an LNAPL recovery pilot program.

A remediation/risk management strategy [RMS]) was completed at the site which involved the installation of an LNAPL recovery system in 2020 to recover liquid phase (LNAPL and water) and vapour phase (soil gas) from the subsurface. The LNAPL recovery system consisted of eleven recovery wells equipped with submersible pumps and a multi-stage treatment system to recover LNAPL and treat recovered groundwater to applicable standards prior to discharge. The active remediation phase is now complete.

In addition to the active remediation step described above, Stantec completed a climate risk assessment as part of an RMS to manage the observed subsurface LNAPL and PHC impacts. Data from previous environmental investigations and climate projections, as well as physical information related to the conceptual site model (CSM) were collected to evaluate their exposure to climate-related hazards, as well as evaluate the consequences of interactions between potential climate hazards and site elements. This type of climate risk assessment was one of the first of its kind completed at a federal contaminated site in Canada.

This presentation will discuss the LNAPL management approaches adopted at the Kraut Point SCH for managing environmental risk at a federal contaminated site, with special focus on the remediation and risk management strategies adopted which includes the implementation an LNAPL recovery system and the completion of a climate risk assessment. The presentation will also present some of the challenges and solutions associated with the installation, maintenance, and operation of an LNAPL recovery system at a tidally influenced active commercial fishing wharf.

Sam Caldwell

Sam Caldwell is an Environmental Engineer-In-Training with Stantec Consulting Ltd. in Dartmouth, Nova Scotia, and has five years' experience in the environmental consulting industry. Sam's work with Stantec focuses primarily on site assessment and remediation of contaminated sites, with focus on contaminated sites northern Canada. Sam received a Bachelor of Applied Science degree from the University of Waterloo.

Risk of Undetected Gas Emission Venting and Migration

Ryan Doull, 360 Energy Liability Management

Oil and gas wells present a risk that not all stakeholders are aware of, this presentation will provide a general understanding and knowledge to identify potential problems. We will review the petroleum well related risks, including gas migration and surface casing vent flow, and required resources to mitigate them quickly and adequately, if identified.

Events in Ontario and other regions have highlighted the need for an awareness to assess these risks and advise emergency services enabling them to have tactical support in place to avoid potential tragedy. The conditions of the abandoned gas well adjacent to the explosion in Wheatley, Ontario in August of 2021 will be discussed as well as ongoing site support to the Wheatley emergency situation and investigation.

A general overview of regulatory and stakeholder considerations will be given along with a review of the differences between detecting utility leaks and oil and gas well issues including recommended options to deal with each scenario. Attendees will be able to apply the information presented to ensure systems and resources are put in place to protect property and the public while assisting to mitigate or completely avoid incidents.

Ryan Doull

Ryan Doull is an upstream oil and gas services executive with 24 years of industry experience. Much of his time was spent leading the foremost Well Integrity services and consulting firm in Western Canada after managing field operations and directing technology and innovation at the company. During his time there he co-invented a class-leading well emissions monitoring technology. Ryan formed, fostered and contributed to industry alliances with complementary organizations in operations technology, emissions monitoring, carbon trading, ESG software and well abandonment engineering & execution disciplines. He has served as a technical champion and liaison on various committees and co-authored/delivered presentations at events such as the North American Well Integrity Workshop (Pittsburgh, 2014), Apple Canada Innovation in Industry (2014), Alberta Gas Migration Impact Study Pilot (Calgary, 2015), the SPE Thermal Well Integrity & Design Symposium (Banff, 2017) and the Ontario Association of Fire Chiefs AGM and Conference (2022). Ryan is a content contributor to Alberta Energy Regulator's Directives 013, 020, 079 and 087 and works at 360 Energy Liability Management in Calgary as a Liability Specialist focused on emissions.

Bioaugmentation- It's Not Just for TCE Anymore

Corey Scales, Jen Webb, Sandra Dworatzek and Kayla Finney, SiREM

Bioaugmentation is the addition of beneficial microorganisms to enhance bioremediation of recalcitrant compounds. Some of the benefits of bioaugmentation include extending the range of sites where cost effective bioremediation is feasible and reducing clean up times for sites where remediation progress may be lagging. Bioaugmentation for remediation of chlorinated ethenes, such as trichloroethene (TCE), is routine and has been applied successfully at a large number of sites in Canada and hundreds of sites worldwide. With regulatory approvals and more widespread utilization of bioremediation, bioaugmentation and biostimulation approaches are now being considered and applied more routinely in Canada. Bioremediation is a green and sustainable remediation approach for contaminated groundwater.

Trihalogenated compounds 1,1,1-trichloroethane (1,1,1-TCA), chloroform (CF), and chlorofluorocarbon (CFC 113) can be inhibitory to *Dehalococcoides (Dhc)* in the reductive dechlorination of chlorinated ethenes to ethene. Our understanding of biodegradation pathways for a growing range of contaminants is growing rapidly. Bioaugmentation cultures targeting a wider range of contaminant classes including chlorinated ethanes (e.g., 1,1,1-TCA/1,2-DCA) chlorinated methanes (e.g., chloroform and methylene chloride), and chlorofluorocarbons (e.g., CFC 113) will soon be available for bioremediation in Canada. Cultures for degradation of benzene and other BTEX compounds under anaerobic conditions are currently available for bioremediation in Canada, making the often challenging, addition of oxygen to aquifers unnecessary and allowing bioremediation options for comingled plumes to be a reality.

This presentation will provide an overview of the suite of bioaugmentation cultures being applied for bioremediation of an expanding range of recalcitrant compounds. As well, the presentation will include several case studies where bioaugmentation has been successfully used under challenging conditions.

Corey Scales

Corey is the Bioaugmentation Coordinator at SiREM with technical experience in the growth, scale-up, and field implementation of several anaerobic microbial bioaugmentation cultures to degrade contaminants including chlorinated solvents, petroleum hydrocarbons, and other recalcitrant compounds. Throughout his career, he has provided technical support throughout the planning, injection, post-injection monitoring and data analysis stages for hundreds of field bioaugmentation events. He is focused on providing insights for optimal bioremediation success.

Field Applications of Anaerobic BTX Bioaugmentation Cultures

Sandra Dworatzek, Jennifer Webb and Corey Scales, SiREM
Courtney Toth and Elizabeth Edwards, University of Toronto

Anaerobic bioaugmentation cultures for Benzene, Toluene, Ethylbenzene and Xylene (BTEX) have been identified, investigated, and demonstrated to completely degrade BTX into carbon dioxide and methane. This occurs in the absence of molecular oxygen and is what makes these cultures unique and useful for anoxic field applications where alternative (aerobic) remediation approaches may be impracticable or impossible to implement. The cultures, collectively referred to as DGG-Plus™ include a methanogenic benzene enrichment culture (DGG-B™), toluene degrading culture (DGG-T™) and a o-xylene degrading culture (DGG-X™) originally developed at the University of Toronto. The microorganisms responsible for benzene, toluene and o-xylene (BTX) transformation have been identified and both molecular biological tools for these bioaugmentation cultures have been laboratory and field tested. In Canada, these cultures, now have been assessed through Environment Canada's New Substance Notification (NSN) program and can be used at sites across the country and globally.

Results from laboratory treatability studies demonstrated enhanced benzene, toluene and o-xylene biodegradation rates with DGG-Plus™ bioaugmentation and provided information to aid in field pilot-test design. A field pilot-test performed at a site in Saskatchewan included three injection points, two of which receivedup to 10 liters of the DGG-B™ culture with four additional bioaugmentation points were added to the site two years later. Benzene degradation rates were accelerated in situ through bioaugmentation as observed in corresponding treatability studies. Additional field applications (in Ontario, British Columbia and the US) where bioaugmentation with the DGG-Plus culture occurred are also being monitored.

These first-to-field projects have helped to establish a better understanding of dosing requirements, timeframes for obtaining results and ranges of conditions over which the cultures are effective. As with chlorinated solvents, bioaugmentation for BTEX compounds has the potential to decrease remediation time frames and increase the range of sites to which bioremediation is applicable providing a much-needed, cost-effective alternative for BTEX remediation in groundwater.

This presentation will summarize data from regulatory approvals and highlight several field applications (both pilot and full-scale) where these anaerobic cultures were used.

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Sandra Dworatzek

Ms. Dworatzek is a Principal of SiREM, a division of Geosyntec Consultants. SiREM maintains state-of-the-art biotreatability, molecular testing and microbial culture development facilities, and currently manages maintenance and culturing of KB-1® , KB-1®

Plus, DGG™ Plus, and DXO-88™ microbial cultures that have been widely used in field demonstrations to improve the rate and extent of bioremediation in groundwater for chlorinated solvents; benzene, toluene and xylene: as well as 1,4-Dioxane. She provides technical oversight for the development of new bioaugmentation cultures for a wide range of emerging contaminants including 1,2,3-trichlorpropane, perchlorate and sulfolane).

Ms. Dworatzek is an environmental microbiologist with advanced technical experience in laboratory treatability studies. Over the past 29 years she has conducted and overseen numerous bench-scale studies examining enhanced in situ bioremediation in groundwater. She has specific technical experience in the design of laboratory treatability studies, the scale up of growth of aerobic and anaerobic microbial cultures for laboratory and field pilot tests, and evaluation of aerobic and anaerobic bioremediation, zero valent iron and chemical oxidation technologies in the laboratory.

Understanding Temperature Effects on Bioremediation and Cleanup Timeline: Case Studies

B.J. Min, TRIUM Environmental

Bioremediation has been widely applied to cost-efficiently remediate sites contaminated with hydrocarbons, chlorinated solvents, and heavy metals in many countries. This remediation technique can be favoured due to its sustainable features including less destructive cleanup process, little to no negative impact on humans and other on-site receptors, long lasting effectiveness, and responsiveness to residual back diffusion of contaminants in difficult geologies. In Canada, remediation experts are often reluctant to implement this technique because of perceptions and understandings that cold temperature and long winter periods are barriers to achieve successful bioremediation. However, successful bioremediation cases under cold conditions in northern Europe and Canada (< 10°C) have been reported over the past decades. Therefore, understanding temperature effects on bioremediation and lessons learned from the successful cases are important to evaluate its feasibility and develop implementation strategies for successful bioremediation in cold regions.

This presentation will use case studies and various published studies to describe the effects of temperature on bioremediation of organic contaminants including hydrocarbons and chlorinated compounds. Specifically, temperature effects on microbial activities/growth and biodegradation rates of the organic contaminants will be discussed. In addition, successful bioremediation cases under cold conditions will be introduced and limitations from those cases will be discussed in the aspects of implementation feasibility in Canada. This presentation will also introduce methods to estimate the site cleanup timelines based on biodegradation kinetics and lag periods, along with factors to be considered in the estimation. Enhanced bioremediation technologies will be also discussed as approaches to overcome these limitations to success in cold regions.

B.J. Min

Mr. B.J. Min, M.Eng., P.Eng. is one of the founders of TRIUM Environmental and currently serves as CEO of TRIUM. Mr. Min obtained his Bachelor of Science in Environmental Engineering from Ajou University in South Korea and his Masters' degree in Environmental Engineering from the University of Calgary in Calgary, Alberta. He leads the corporate management as well as new ventures teams including R&D and commercialization of new products/services, intellectual property planning & licensing, and international joint ventures.

Engineering a Sustainable Remediation Approach

Suvish Melanta and David MacGillivray, Grounded Engineering Inc.

This presentation explores how planning, engineering, and construction come together when developing a brownfield site. Three different brownfield case studies in the Greater Toronto Area are presented wherein Grounded has provided multi-disciplinary solutions driven by more than the contamination present below the ground. Remediation approaches are commonly chosen as a result of difficult or complex geotechnical, hydrogeological, and geo-structural requirements. Each project case study delves into the unique subsurface conditions and environmental quality, and present how these multi-stakeholder drivers led to the preferred brownfield redevelopment approach. Some of the solutions include the use of helical piles, caisson shoring systems, and groundwater control systems. The presentation provides a qualitative evaluation of the environmental sustainability for various construction approaches at each project site.

Suvish Melanta

Ms. Suvish Melanta, M.Sc., P.Eng. works primarily in environmental site assessment, remediation, and hydrogeology. She has a Bachelor's degree in biological engineering from the University of Arkansas and a Master's degree in civil and environmental engineering from the University of Maryland. She applies her knowledge and skills to bring innovative solutions to Brownfield redevelopment sites. Her career experience has included assignments involving Hydrogeological Assessment, Brownfield Redevelopment, Environmental Risk Assessment, Environmental Site Assessment, Record of Site Condition, Soil Vapour/Indoor Air Assessments, and Excess Soil Re-Use. Suvish is registered with the Ontario Ministry of the Environment as a qualified person (QP) to conduct environmental site assessments.

Keys to Successful In-Situ Remedial Design at Brownfields Sites: A Comprehensive Approach Utilizing Design Verification Testing and Flux Tracer Tools

Elliot Maker, Regenesis

Remediation of contaminated sites, specifically brownfields, requires a strategic approach that ensures the remediation's effectiveness while minimizing costs and time to closure. This presentation explores the keys to successful in-situ remedial designs at brownfields sites.

The technical approach involves establishing a fundamental understanding of the site conceptual model (CSM) and remedial goals. A comprehensive site investigation is essential in determining the extent and nature of contamination. This is followed by the selection of appropriate remediation technologies, including physical, chemical, and biological methods.

Pre-application evaluation, including design verification testing (DVT), is crucial in ensuring the effectiveness of the remediation design. The methods and procedures implemented in DVT, along with an overview of the results, will be discussed. Furthermore, Flux-Tracer, a novel in-well monitoring tool, will be introduced to identify contaminant mass flux within the subsurface. Thus, allowing for the design of a remediation system that targets the pathways of contaminant migration.

Application is vital to all in-situ remedial approaches. An overview of our experience successfully implementing in-situ projects across the country, with a focus on lessons learned, will be provided.

Finally, a case study demonstrating the successful implementation of our in-situ remedial design approach at a brownfields site will be presented. The case study will highlight the effectiveness of our approach in remediating a contaminated site while minimizing costs and time to closure.

In conclusion, the keys to successful in-situ remedial design at brownfields sites are a strategic approach, including a thorough site investigation, the selection of appropriate remediation technologies, pre-application evaluations, and thoughtful application. By implementing these key factors, in-situ remedial design projects can achieve their goals and ensure a safer and more sustainable environment.

Elliot Maker

Mr. Maker, M.Sc. is an Engineer in Training (EIT) with a Masters of Science in Civil and Environmental Engineering from the University of Vermont. He has extensive experience in the environmental industry, having worked for several leading firms in the Northeast.

During his time at the University, Elliot conducted field and laboratory research with the Vermont Department of Environmental Conservation and worked in the Water Treatment and Environmental Nanotechnology Lab. His research project consisted of the classification, quantification, and potential green nanoremediation of per- and polyfluoroalkyl substances (PFASs).

Elliot's professional experience includes Phase I and Phase II site assessments, soil and groundwater sampling, remediation, and project management. Currently, as the Northeast District Manager at Regenesis, Elliot is responsible for managing all design and implementation of Regenesis projects in the American Northeast and Eastern Canada. Elliot works closely with environmental consulting firms to develop effective remedial approaches by offering design, application, and performance review services for in-situ groundwater and soil remediation projects.

(The) Redevelopment of Oshawa Harbour – Conversion of Federal Contaminated Land into a Municipal Waterfront Park through Site Assessment, Risk Management, and Soil Management

Pamela Cameron and Trevor Mahoney, XCG Consulting Limited

In Ontario, converting industrial land to a park requires completion of a Record of Site Condition (RSC) in accordance with Ontario Regulation (O. Reg.) 153/04. Although, such conversions are not uncommon, such projects can still be challenging. The Oshawa Harbour project presented a unique combination of issues and challenges due to the transfer of contaminated, industrial lands owned by the Federal Government to the City of Oshawa for parkland use, encroachment of the site on flood plains, waterfront setting and involvement of several levels of governments and several regulatory agencies.

The presentation will focus on the challenges of completing an RSC project with a fixed, hard deadline, using a risk management approach, while dealing with the Federal, Provincial and Municipal governments as well as a local conservation authority.

Additional challenges discussed in this presentation include completing an excess soil project before and during the early days of the excess soil regulatory regime (aka the Good Old Days).

The presentation will describe the various stages of the project, including the selection and design of the remedial approach and the risk management measures given the proposed future use of the site, the on-site environmental conditions, the site setting, and the hard deadline set by the Federal Government for completion of the RSC. Challenges during implementation and maintenance of the risk management measures during the park construction activities and post construction period will also be covered.

Pamela Cameron

Pamela Cameron, B.A.Sc., P.Eng., QPRA, QPESA, Senior Project Manager/Risk Assessor is a Professional Engineer with over 25 years of experience in environmental site assessment. Ms. Cameron is a Qualified Person (QP) for both Environmental Site Assessment (QPESA) and Risk Assessment (QPRA) in accordance with Ontario Regulations. Ms. Cameron is a Senior Project Manager in XCG's Kitchener, Ontario office and is a licensed Professional Engineer in the provinces of Ontario, Alberta, and Nova Scotia.

Ms. Cameron is a leader within XCG's Environmental Site Assessment and Risk Assessment Group and has been helping clients solve environmental issues with XCG since 1995. Over the 25 years, Ms. Cameron has managed hundreds of Phase I and Phase II Environmental Site Assessments for a variety of private and municipal corporations. She's been a risk assessor in multiple Risk Assessments prepared in accordance with Ontario Regulations for brownfield redevelopment projects and is very well versed in the Ontario site assessment/remediation process. She has also assisted numerous Ontario-based clients obtain Environmental Compliance Approvals (ECA) for Air Emissions, and more recently has helped clients transition to the new Air Emissions Environmental Activity and Sector Registry (EASR).

Use of Debris-containing Soil for a Stormwater Pond – The Case for Sustainable Remediation

Michael Lupart, Trace Associates Inc.

The objective of this presentation is to share information around the discovery, investigation, remediation and subsequent re-use of approximately 30,000 cubic metres of buried soil containing debris that was integrated into the development of a stormwater pond in Calgary, Alberta. The presentation will highlight technical details as well as critical regulator and stakeholder engagement surrounding the development of the stormwater pond. Trace will present a sustainability summary that assisted the overall approval and development of the stormwater pond.

Soil and debris was initially encountered within a backfilled natural ravine in Calgary in 2015. The debris was interpreted to have originated from building demolition waste mixed with soil and placed in the ravine.

Initially concentrations of metals, petroleum hydrocarbons, and polycyclic aromatic hydrocarbons in soil did not meet the applicable generic environmental guidelines. The contamination was interpreted to be directly related to the construction debris which comprised brick, concrete, metal, wood, cloth and glass.

Through multiple conversations with the regulator, the City of Calgary, and the landowner and developer it was agreed to evaluate the potential use of the soil containing debris in the construction of a dry storm-water pond. Multiple environmental assessments including soil and groundwater investigations and a site-specific risk assessment were conducted to characterize and categorize impacts. Partial remediation was conducted to remove impacted soil and debris.

Trace provided a sustainability summary documenting the net environmental benefit of leaving the soil and debris in place beneath the future stormwater pond. This along, with the assessment information was used to obtain regulatory approval for beneficial reuse of the soil containing debris.

Integrating soil containing debris into the stormwater pond resulted in approximately 25,000 cubic meters of material being diverted from a landfill. Trace will summarize specific sustainability metrics and how they compare to a typical dig and dump scenario including lessons learned throughout the project.

Michael Lupart

Michael Lupart, B.Sc., P.Ag., P.Biol., is the Division Manager, Calgary, and a Partner with Trace, and has over 15 years of experience conducting environmental site assessments (ESAs), groundwater monitoring, spill response, and remediation activities related to land development and upstream oil and gas activities. At Trace, Michael leads the Calgary office and directs work as the Principal-in-Charge for the Real Estate and Development Team. Michael is responsible for senior technical oversight, client liaison, and successful project execution within the real estate, government, oil and gas, and industrial sectors.

Climate Resilient Brownfield Remediation

Meggen Janes and Karen Bechard, Geosyntec Consulting

How climate resilient is your remediation and risk management design? Wherever you are in Canada, there are signs of climate change - record high Lake Ontario water levels, super rainstorms in Montreal, heat waves and forest fires in BC, flooding on the Bow River in Alberta and it goes on. We'll explore how these temporal changes have impacts on brownfield remediation. We don't often think about emergency preparedness in remediation design because our systems tend to be based on longer term performance. Several case studies will be used as examples of remediation and risk management failures from extreme events. We'll explore real outcomes from extreme events and what-if scenarios during typical remediation. In remediation and risk assessment planning, future conditions may differ from historic ranges. It is important to assess your brownfield portfolio for vulnerability; a site or project is not always vulnerable in its entirety but there may be aspects or key components of vulnerability. The evolution of brownfield remediation often moves through risk assessment, remedial option evaluation, remediation, and then to long term monitoring. Each step of the process can include considerations/evaluation steps to manage uncertainty and climate risk in your project. Certain risk assessment factors are more sensitive to influences from climate change and the impact of these factors on risk modeling and risk reduction can influence risk management design. Remediation starts with remedy selection; we will discuss how remediation option evaluation (i.e., feasibility studies) can be expanded to consider impact of climate and adaptability of the remedy for temperature, precipitation, wind and wildfires. We will also discuss how extreme climate events may affect long term monitoring programs and monitored natural attenuation. Recommended changes to industry standard practices are needed to manage your brownfield remediation and plan for resiliency in brownfield remediation.

Meggen Janes

Meggen Janes, M.Sc., P.Eng., QPRA, QPESA, is a Principal at Geosyntec. She has over 25 years of experience in brownfield redevelopment, risk based environmental strategies and remediation projects. She has specialized in unique strategies for public realm site redevelopment where use of risk assessment, soil and site management measures have been critical to the success. Meggen has worked on many of Canada's largest remediation projects including Sydney Tar Ponds, Pottersburg PCB Remediation, Brantford's Greenwich Mohawk site and Toronto's Port Lands. Meggen taught a graduate course in Soil Remediation for Ryerson University's Environmental Science and Management program and been a guest lecturer for many college and university programs.

Environmental Insurance: A Case Study Involving Active Litigation, Complicated Site History, and Multiple Transactions!

Carl Spensieri, Berkley Canada

Marc McAree, Willms & Shier Environmental Lawyers LLP

Buying and selling contaminated land is complicated enough under the best of circumstances. Now imagine a property that is subject to multiple lawsuits, was transacted multiple times (i.e., numerous changes in ownership), and has known and possibly unknown soil and groundwater contamination. This is what Marc and Carl will speak about all of which is premised on a recent, actual matter where environmental insurance played an important role in assisting to resolve the litigation and facilitate yet another sale. Attendees will learn about how creative negotiations, thoughtful purchase and sale agreement conditions, strong consultant's reports, and open discussion about what environmental insurance can and cannot do was applied to allocate environmental risk.

Target Audience: Developers and real estate owners; municipal, city and provincial government agencies responsible for managing real estate; and environmental consultants and contractors.

Carl Spensieri

Carl Spensieri, M.A.Sc., LLB, P.Eng. leads the Environmental Team at Berkley Canada, a niche specialty insurance carrier. Carl focuses on delivering better outcomes for clients by using his expertise to find creative risk transfer solutions for environmental risks. Prior to underwriting, Carl was an environmental engineer working with a Toronto based environmental consulting company. He has also worked at a Canadian law firm, within their environmental law group. Carl's areas of expertise include merger & acquisition due diligence; professional liability; environmental liability assessment and risk transfer; property transactions; and Canadian infrastructure projects.

Carl holds a Masters of Applied Sciences and Engineering from the University of Toronto and a Bachelor of Laws from the University of London (UK). He is also a Professional Engineer (Ontario).

Marc McAree

Marc McAree, B.A. (Hons.), LL.B., M.E.S., is a partner at Willms & Shier Environmental Lawyers LLP and certified as a Specialist in Environmental Law by the Law Society of Ontario.

Marc provides advice and solutions to a wide range of clients to overcome their environmental law and litigation issues. Marc has significant environmental law expertise in contaminated land/brownfields clean ups, transactions, environmental compliance and approvals, and litigation. Marc regularly counsels clients about how best to reduce and manage environmental risks and liabilities.

Marc is recognized for his excellence representing clients in environmental civil litigation at all levels of Ontario Courts, defence of clients against environmental regulatory prosecutions, and appearances before administrative tribunals mostly on appeals of regulatory orders and environmental approvals. Marc has particular experience litigating soil, groundwater and vapour contaminant impacts, nuisances and odour issues.

Marc is named in the 2023 *Lexpert/American Lawyer Guide To The Leading 500 Lawyers in Canada*. He is peer selected annually for inclusion in the Best Lawyers in Canada for environmental law. Marc was named "Environmental Lawyer of the Year" for 2019 in Toronto by the *Best Lawyers in Canada*. Marc is also ranked "Most Frequently Recommended" by the *Canadian Legal Lexpert Directory* and ranked "AV Preeminent" by peers in *Martindale-Hubbell*. He is also named annually in both the international *Who's Who Legal—Environment* and *Who's Who Legal—Canada*. Marc is called to the Bars of Ontario and British Columbia.

How Do You Drown a Tree? and Other Unique and Challenging Construction Aspects…

Nicholas Doucette, QM Environmental

What is a drowned tree? Is it dead or alive? What does it do? What kind of animals use it as habitat? But most interestingly how do you build one?

Large scale infrastructure projects are becoming more complex in their intent and design every day. They are almost all highly multi-disciplinary in terms of scope integration and execution. Their frequency in the future will become greater as the population of earth increases and that population grapples with climate change through resiliency infrastructure and the application of natural based solutions. Construction of these projects is considerably more challenging as their designs become more sophisticated and integrated. Pulling off these projects will require innovation and creative thinking from all stakeholders in the face of new, complex, and the logistically impossible.

This presentation intends to give you a contractor's perspective on triumphs and lessons learned on delivering unique and complex elements of a large-scale multidisciplinary climate resiliency waterfront infrastructure project. From tracking tens of thousands of loads of materials and capturing millions of survey data points while excavating a deep channel through a former lakebed and then constructing a lined containment below groundwater level; to sequencing the construction of a variety of finish materials to shape a river with construction of habitat features at scales never built before, or demolition of dockwalls and excavation of a historic port leaving future islands in place, and of course blind subaqueous tie in of marine elements such as reactive barriers and scour protection.

The Port Lands Flood Protection and Enabling Infrastructure projects is one of the largest brownfield redevelopment projects in North America. More than one billion dollars is being invested by municipal, provincial and federal levels of government to clean up the Port Lands and protect the area from flooding by naturalizing the mouth of the Don River. The project will provide over 50 acres for high-value waterfront development, including parks and improved habitat. Construction of the new river valley created the requirement for a robust isolation barrier to prevent impacts from residual contamination from soils in the excavated river channel. The project includes a target to reuse over 1.5M m3 of soil excavated from the river channel and associated infrastructure as part of the design.

Nicholas Doucette

Nicholas Doucette, P.Eng., QM's National Manager for Special Projects, is an environmental contractor that is a passionate advocate for innovation in the pursuit of safer, more sustainable environmental remediation projects. He is responsible for the bidding and delivery of complex, large, and/or sensitive Environmental Remediation projects across Canada including marine, civil, and specialty construction. Mr. Doucette has worked on projects from coast to coast including the Sydney Tar Ponds, Port Lands, Port Hope, Rock Bay, and Esquimalt Harbour projects. He currently leads QM's Toronto Port Lands Project portfolio, presently valued at over $180 million.

Technical and Strategic Considerations for the Use of Risk Assessment at a NAPL-Impacted Brownfield

Paul H. Cheung and Peter Sutton, Terrapex

As the population of the GTHA continues to grow and housing affordability is tightened, brownfield redevelopment offers a unique opportunity to ease supply concerns, but challenges remain. Current environmental regulation and policy in Ontario leaves little accommodation for brownfields impacted with free-phase petroleum and while it is imperative that practitioners and regulators continue to provide risk-based protections, these properties represent an under-explored opportunity for addressing housing needs.

This case study will review the technical and regulatory challenges and stakeholder considerations for a brownfield property impacted with free-phase petroleum and will outline the development and successful execution of a risk assessment-based solution for a residential redevelopment of the property. The review will also explore the substantial challenges posed by regulator policies to the redevelopment of brownfields impacted with free-phase petroleum.

Paul H. Cheung

Paul H. Cheung, M.Env.Sc., QPRA is an environmental risk assessor and project manager at Terrapex responsible for the completion of human health and ecological risk assessments for brownfield properties impacted by historical activities under Provincial (Ontario Regulation 153/04), Federal (Canada FCSAP), and US State (California DTSC) regulations and frameworks.

Paul is a Qualified Person in Risk Assessment (QPRA) under O. Reg. 153/04 and has contributed to or completed over 25 risk assessments accepted by the Ontario Ministry of the Environment, Conservation and Parks (MECP) under O. Reg. 153/04 and over 80 due diligence risk assessments for a variety of industry, real estate developer, and government clients. Paul was part of the project delivery team involved in addressing the environmental challenges at the subject property.

Peter Sutton

Peter Sutton, P.Eng., QPESA, QPRA is Vice President, Environmental Services at Terrapex, responsible for the operations of the site assessment and remediation, risk assessment, ecology, and hazardous materials practice areas at the company. Peter also continues to provide high level environmental consulting services in all aspects of brownfield redevelopment, as well as peer review / expert opinion services to clients in support of due diligence efforts, civil litigation matters, and subrogation claims related to environmental contamination.

Peter is a professional engineer and designated “Consulting Engineer” in the Province of Ontario, with nearly 30 years of experience in investigating, addressing, and managing contaminated soils, groundwater, and sediment. Peter served as QPRA, overseeing the completion of the risk assessment for the project.

Optimizing Ex situ Bioremediation of Recalcitrant Compounds in Canada's Cold Climate

Jean Pare and Malika Bendouz, Chemco

Background/Objectives: Many large-scale projects enhanced bioremediation projects with nutrients and bacterial preparations have been completed in Canada, over the past 25 years. Contaminants treated using this approach include petroleum hydrocarbons, PAHs, phthalates, chlorinated phenols, and chlorinated herbicides. Challenges that must be overcome over the cold climate include low solubility and high acute toxicity of some contaminants as well as stringent remedial standards. Treatment has been conducted both in situ without excavation, on-site following soil excavation, and off-site at permitted soil treatment centers. This approach to soil remediation provides a more economical and environmentally sustainable alternative to excavation, thermal treatment, or off-site soil disposal by landfilling. The presentation will illustrate how specific type of amendments selected based on soil/contaminant type can increase contaminant destruction rates versus traditional biostimulation techniques.

Approach/Activities: The use of various soil additives including specialized bacteria, surfactants, nutrients, and organic amendments can be evaluated at bench or pilot scale level to promote more rapid and complete destruction of the targeted contaminants either using aerobic or anaerobic pathway. Completion of properly designed bench or pilot-scale testing increases the probability of effective full-scale treatment and attainment of the remedial objectives. Proper design parameters and post-application monitoring will be discussed as these are the critical key factors for successful management of ex situ or in situ bio-stimulation. The soil amendments are typically applied at low dosages and result in very little or no increase in soil volume following treatment. Over the last 25 years, bioremediation in Canada has been used successfully for in situ and ex-situ treatment of soils contaminated with a broad range of chlorinated and non-chlorinated recalcitrant compounds despite limitations imposed by Canada's cold climate.

Results/Lessons Learned: Detailed results from representative bench-scale testing and completed full-scale projects in Quebec, Ontario, and Alberta will be presented. Contaminants treated include chlorinated pesticides (DDT, Dieldrin) and herbicides (bromacil), pentachlorophenol, and PAHs. Performance and cost information will be reviewed. The full-scale project results will be used to illustrate attainable removal efficiencies as well as recognized limitations to this type of soil remediation. perspectives of performance and cost. These brief case studies will illustrate attainable removal efficiencies as well as recognized limitations to this type of soil remediation

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Jean Pare

Jean Pare, P.Eng., has a degree in Chemical Engineering from Laval University. He has been involved for the last 25 years in the evaluation, development, design, and promotion of both conventional and innovative environmental technologies. As Vice President with Chemco Inc., his responsibilities include the remediation design, technico-economical analysis and technology supply for chemical oxidation and reduction, soil washing, and enhanced bioremediation. Last year, he worked with over 400 sites applying his expertise to various types of organic and inorganic contaminants in soil and groundwater. He is also involved with many environmental organizations such as CLRA, CBN, ESAA, BCEIA and Reseau-Environnement where he is an active technical committee member and regular technical speaker.

Malika Bendouz

Malika Bendouz is the Technical Director at Chemco Inc, since 2019. She earned a Ph.D degree in water sciences from the National Institute for Scientific Research (INRS-ETE). Throughout her academic and professional career, she focused on the development of soil and GW remediation technologies. Which Include the utilisation of oxidative and reductive technologies as well as biological remedies to remove the common contaminants such as: PAH, chlorinated compounds, pesticides, petroleum hydrocarbons and more.

As a Technical Director of Chemco Inc., her primary role is the techno-economic evaluation of contaminated sites, the selection of the appropriate technology based on site specific data, and the innovative environmental technologies that reduce compliance costs and maximize clean-up efficiency. Mme Bendouz would coordinate laboratory services and analysis including bench scale treatability testing in saturated and unsaturated conditions, Groundwater parameter analysis, qualitative and quantitative tracer study, Soil and Groundwater Oxidant Demand Evaluation (SOD)» to determine the best approach as well as economic justification to achieve the remediation objective for Soil and GW."

Treatability Options for Metals Contaminated Sites

Larissa Smith, Kela Ashworth and Michael Healey, SiREM
Cory Repta, Geosyntec

Contamination of soil, sediment and groundwater with potentially toxic heavy metals is common. Technical approaches to their remediation can be complex given the sensitivity of metals to geochemistry, in particular pH and redox potential. Remedial efforts such as the addition of electron donors can alter the redox state of an aquifer, thereby affecting the solubility and mobility of metal species. Furthermore, some metals may be toxic to microorganisms and may be inhibitory to bioremediation of other compounds, such as chlorinated solvents, with implications for sites with comingled contaminants.

Laboratory treatability studies are commonly used to evaluate remedial options prior to field implementation for a wide variety of contaminants including metals such as arsenic (As), hexavalent chromium Cr(VI), and chlorinated volatile organic compounds (cVOCs). Treatability studies are valuable tools to assess the impact of amendments (electron acceptors [e.g., sulfate], electron donors, oxidants, zero valent iron [ZVI] and pH adjusting agents) and the effects of remediation efforts under various scenarios.

This presentation will focus on the use of treatability studies to evaluate treatment options for metals and case studies of laboratory batch and column treatability studies will be presented. In one study, a flow through column was used to evaluate As mobility through a ZVI barrier and the As removal capacity with a commercial ZVI product was determined. In another study, a batch microcosm study was constructed to evaluate pH adjustment and lactate amendment for the reduction of Cr(VI) in site materials. After promising results from the batch test, a column study was undertaken to model the movement of groundwater through the Site materials. One column was successful in reducing the Cr(VI) concentration from 600 milligrams per liter (mg/L) to less than 1 mg/L. The microbial community in the column was analyzed to identify the microorganisms present and was used to determine a possible mechanism of Cr(VI) reduction. Finally, a fifteen column study was constructed with materials from four aquifer sources to test different commercial ZVI amended dosages and electron donor sources for the treatment of Cr(VI) and cVOCs. The multi-column study determined that both ZVI and electron donor amendments were able to effectively treat Cr(VI) and cVOCs and the results will be used to optimize the remedial design in the field.

Larissa Smith

Larissa Smith, MSc is a Scientist in the Treatability division of SiREM. SiREM maintains state-of-the-art treatability, molecular testing, passive sampler, and microbial culture development facilities.

Ms. Smith holds a Master of Science in Chemistry from Queen's University. Larissa has been working at SiREM since 2020 and has managed numerous bench-scale studies evaluating remediation technologies for contaminants including chlorinated solvents, petroleum hydrocarbons, metals and other recalcitrant compounds in soil, sediment, and groundwater. Larissa has several years of metals and mining related experience and is keenly interested in metals remediation.

Using Geochemical Data to Trouble Shoot Variable Performance Following ISCO

Brant Smith, Josephine Molin and John Valkenburg, Evonik
Jean Pare, Chemco

Background/Objective. Due to heterogeneous site conditions and other challenges, In Situ remediation technologies sometimes result in a varied response, especially if applied via injection The variation in performance can have a multitude of explanations, including under dosing, lack of distribution / contact, insufficient contact time, rebound from sorbed mass or recontamination from inflowing groundwater over time. Following the application of activated persulfate, there are a number of geochemical parameters that could be monitored for to help distinguish between these different factors. This then allows modifying the remedial action plan appropriately for the next phase. This presentation will provide a review of actual performance data from various ISCO project sites and discuss performance relative geochemical response.

Approach/Activities. Key geochemical parameters used to assess persulfate applications included direct measurements of persulfate, electric conductivity (EC), sodium or potassium, sulfate, pH, and ORP. The timing of the geochemical response was used to evaluate whether a monitoring location was immediately impacted by the persulfate injections or impacted over time, either by persulfate or its breakdown products. Concentrations of persulfate and its breakdown products (sodium or potassium and sulfate) was compared to the dose rates applied to validate substrate distribution and longevity. Sodium or potassium are particularly useful to assess distribution and flow paths as it stays in solution and acts as a conservative tracers.

Results/Lessons Learned. In reviewing the variation in treatment performance relative changes in geochemical parameters, it was often possible to determine the underlying cause of the mixed results. For example, variations in EC / sodium concentrations over time could help distinguish between true rebound vs recontamination. The disappearance of a geochemical footprint (persulfate indicators) over time suggested that new, untreated groundwater migrated into the area, in some cases recontaminating the groundwater. Conversely, a rebound in contaminant concentrations occurring while EC and sodium remained elevated suggested a true rebound where sorbed mass reequilibriated into the groundwater phase after the persulfate was spent. This distinction helped guide the next action at these sites, whether a second application was recommended (in the case of a true rebound) or an expansion of the treatment area to address the source (in the case of recontamination from inflowing groundwater). Review of groundwater concentrations of persulfate and breakdown products also showed that mixed results often could be explained by a variation in substrate distribution, requiring a modification to the application approach to obtain more homogeneous placement and more complete treatment at those sites.

Brant Smith

Dr. Brant Smith is Technology Director for Persulfates and Soil & Groundwater for Evonik Active Oxygens group. With over 20 years of experience, he has designed and implemented numerous field applications and bench scale tests involving ISCO, in situ bioremediation, in situ chemical reduction, and metals stabilization. He has helped author over 90 presentations at national and international conferences and his research has been published in journals including *Environmental Science and Technology*, *Journal of Contaminant Hydrology*, *Environmental Toxicology and Chemistry*, *Journal of Environmental Science and Health*, and *Journal of Environmental Engineering*. Dr. Smith obtained a B.Sc. with the majors of Civil and Environmental Engineering and Economics from Worcester Polytechnic Institute, and a M.Sc. and Ph.D in Civil Engineering from Washington State University. He is a registered Professional Engineer in Washington State.

(The) Intersection of Excess Soil Management and Site Remediation in Ontario

Grant Walsom, XCG Consulting Limited

With the final piece to Ontario Regulation 406/19 (On-site and Excess Soil Management) now in force, understanding how the requirements of the Regulation intersect with Site Remediation activities completed within the Regulation 153/04 (Brownfields) is important for Brownfield owners and practitioners. Requirements of the Excess Soil Regulation cross over into the traditional Site Remediation process, some of which are not commonly known.

This presentation will identify the requirements of Regulation 406/19 that apply to the site remediation procedures that include excavation and transportation of soil to treatment facilities or landfills for disposal with examples. The presentation will also delve into activities that may be applicable for consideration in minimizing excess soil to be relocated to another property such as reuse of valuable materials, adjusting designs and grades for the development, or geotechnical ground improvements.

Examples of questions that will be answered include:

- Does my dig-and-haul site remediation require to be filed on the Excess Soil Registry?
- Do I need to complete the minimum sampling requirements and frequency for a contaminated soil zone?
- Is there any QP discretion for sampling outside the Area of Potential Environmental Concern?
- Do I need to track my soil movements from the source site to the disposal location?
- How can I minimize the volume of excess soil that is being relocated from my project area?

Grant Walsom

Mr. Walsom, B.A.Sc., P.Eng., QP is a senior remediation engineer with over 28 years of experience. He is a Partner and Senior Project Manager at XCG Consulting Limited. Mr. Walsom is a Professional Engineer registered in Ontario and Alberta, and a registered Consulting Engineer in Ontario. In addition, Mr. Walsom is a Qualified Person as defined by the Ontario Regulations (O. Reg.) 153/04 and 406/19.

His expertise has included Phase I and II Environmental Site Assessments (ESAs), Site Remediation, Excess Soil Management, and Compliance Audits (for external and pre-acquisition purposes). He has completed numerous Brownfield redevelopments projects with Records of Site Condition (RSC) and remediation for soil and groundwater with virtually all contaminant sources, including metals (including arsenic, copper, lead, zinc, and cyanide), petroleum hydrocarbons (PHCs), chlorinated volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs, including coal tar), and polychlorinated biphenyls (PCBs).

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Mr. Walsom currently is the past-Chair of the Board of Directors for the Ontario Environment Industry Association (ONEIA) and former co-Chair for the Excess Soils Working Group of the Brownfield Advocacy Committee. Mr. Walsom has also served on the Board of Directors for the Canadian Brownfield Network (CBN) as Vice-President, President, and Past-President. He has proudly been involved with the Ontario Ministry of the Environment, Conservation and Parks (Ministry) through the implementation of O. Reg. 406/19 (On-site and Excess Soil Management). Mr. Walsom proudly founded the Qualified Persons Community of Ontario (QPCO) in 2021. He continues as Chair of QPCO and actively participates in the three advocacy teams with the Ministry.

Mr. Walsom enjoys participating in speaking engagements and presentations regarding site remediation case-studies, Brownfield redevelopment, and excess soil management. He is currently representing ONEIA in the Ministry of the Environment, Conservation and Parks Excess Soils Engagement Group for the implementation of new excess soil management rules and regulations in Ontario. He led the steering committees and creation of the Excess Soils Best(OSPE). Mr. Walsom has participated in the organizing committee and/or presented at the Soils Symposiums held in Ontario in 2016 through 2021.

STARx Treatment Plants: Smouldering Hydrocarbons, Waste Products, Contaminated Soils, and Recalcitrant Compounds at Scale

Dave Liefl, Savron

Smouldering is a self-sustaining remediation process following a short duration, 'ignition event' for low volatility, high energy compounds such as petroleum hydrocarbons, and has been used to remediate impacted soils and destroy liquid organic wastes at midstream / upstream oil and gas facilities and brownfields redevelopment sites worldwide. When additional surrogate fuels are included, smouldering has also been proven to destroy low energy recalcitrant compounds such as PFAS within impacted soils and filter media.

Ex situ smouldering, referred to as STARx is typically carried out in scalable engineered Hottpad base systems. In 2022, STARx equipment was deployed to treat hydrocarbon waste products, hydrocarbon-impacted soils, and chloronitrobenzene-impacted soils at Client Sites in the Caribbean, the Middle East, and in Brazil, respectively.

Active operations of a two HP-250 Base System Plant (500 m3 capacity) is underway at a terminal facility in the Caribbean targeting treatment of 11,250 m3 of consolidated oily sludge generated during Hurricane Dorian clean up activities. Due to sludge heterogeneity, two concurrent treatment methods were deployed to maximize overall Plant processing rate: less viscous pumpable oil is diverted to an oil incinerator, while non-pumpable sludge is diverted to STARx.

Active operations of a four HP-250 Base System Plant (1,000 m3 capacity) is also underway at an operating oil field in the Middle East targeting the co-treatment of 300,000 m3 historic hydrocarbon waste products and contaminated soils. Arid desert conditions and high sludge sulphur content required additional process air filtering and emissions treatment equipment. Plant processing rates were improved via remote support from Savron's technical support team, with efforts focused on improved system control and material handling methods.

Pilot STARx equipment was also mobilized to treat low energy chloronitrobenzene-impacted soils at a former chemical manufacturing facility in Brazil. Building upon experience gained through the successful treatment of PFAS contaminated soils using supplemental fuels, granular activated carbon (GAC), and local biomass materials such as coconut husks and eucalyptus bark, were assessed in the context of Client-developed key performance indicators and sustainability metrics. Based on shorter ignition times, higher processing rates, local availability, and economic considerations, coconut husks were selected as the supplemental fuel of choice for full scale treatment.

This presentation will provide a summary of each project's management and engineering considerations, and construction and commissioning activities. Developed solutions required to overcome operational challenges will be shared along with real time Plant performance metrics for currently operating facilities.

Dave Liefl

Mr. Liefl is a Senior Engineer at Savron with 13 years' experience in the environmental consulting and thermal remediation industries. His primary duties include operations management of Savron's full scale plants/projects, as well as supporting STAR/STARx product development in conjunction with Savron's Engineering and R&D groups.

Legacy Hydrocarbon Production and Related Factors Contributing to Degraded Groundwater Quality in Southwestern Ontario

Stewart Hamilton, Matrix-Solutions

The Ontario Oil and Gas industry is small by global standards but arguably the oldest, with the first oil well drilled in 1858, a year before the famous discovery of oil in Pennsylvania. Only 27,000 wells are recorded to have been drilled in Ontario's 165-year history, compared with 450,000 in Alberta, most of which were drilled since WW2. Regulation in both industries started about the same time –near the beginning of Alberta's industry, but many decades after the start of Ontario's. Another difference is land tenure. In Ontario, mineral rights are held by the property owner but in Alberta, they are leased by the government to large companies, which incentivizes the landowner to proactively engage with regulatory authorities in the monitoring of operations. In Ontario, especially in the past, the landowner very often owned the infrastructure, which reversed the incentive.

Ontario also has unique challenges due to geology. Several lines of evidence suggest the presence of upward regional hydraulic gradients on Pelee Island, the Niagara and Essex Peninsulas and the north shore of Lake Erie. The driving pressure for these gradients may originate from the Allegheny Plateau on the U.S. side of the lake. Thousands of legacy oil and gas wells in these regions may have connected shallow aquifers to deeper subsurface evaporitic strata and allowed the upward movement of "sulphur water". This, coupled with the normal process of upward buoyant gas transport results in large-scale contact between sulphate and methane, resulting in biogenic production of hydrogen sulphide. This is now a widespread problem on the Niagara & Essex Peninsulas, Pelee Island, and incised rivers along the north shore of Lake Erie. It is notably not a problem in other areas for reasons that are not always understood.

Only a subset of the known wells likely contributes to these admittedly serious problems. The bright side is that the total number of problematic wells is far smaller than other jurisdictions have to deal with. With proper prioritization, Ontario could conceivably mitigate many of the more serious problems associated with legacy hydrocarbon production.

Stewart Hamilton

Dr. Stewart Hamilton, PhD, has 35 years of experience as a geochemist, hydrogeologist, and geologist and has worked in several related disciplines including electrical geophysics and geomicrobiology. Prior to his joining Matrix-Solutions in 2022, he was the Senior Science Leader for Geochemistry at the Ontario Geological Survey (OGS), where he worked for almost 28 years. Before this he was a hydrogeologist and geochemist at Jacques Whitford Environment Limited (now part of Stantec). From 2005 to 2007 he served as Distinguished Lecturer for the Association of Applied Geochemists and in 2015 was awarded the Provincial and Territorial Geologists Medal. In recent years, much of his research focused on characterizing, mapping, and understanding the regional groundwater quality trends in Ontario's aquifers, in particular, those related to legacy gas wells.

Optimizing Groundwater Treatment for Complex Construction Sites: 2 Case Studies

Nathan Lichti and Mahshid Jannati, Vertex Environmental Inc.

In the not-so-distant past, groundwater and stormwater accumulation at construction sites was discharged into the nearest storm sewer without a second thought. However, since 2015, there has been a significant shift in the approach taken by municipalities across Ontario. They have begun to tighten their sewer use by-laws, eliminating nuisance water exemptions, and even require some construction sites to treat groundwater to more-stringent storm sewer (i.e., natural environment) standards. This has made groundwater treatment a critical design component at almost every construction site. Whether due to historic contamination, naturally occurring metals, or construction-related products such as de-icers and PHCs, treatment is now a necessity rather than an afterthought!

Design of treatment systems for construction sites can pose significant challenges, including managing high daily volumes of water with limited space, accommodating site-specific constraints such as power availability, sewer capacity limits, and municipal backwash rules, as well as treating recalcitrant dissolved metals to meet storm sewer standards. In light of these constraints, relying on "copy and paste solutions" can prove to be expensive or worse, delay or shut down the entire construction site. Therefore, treatment systems must be custom-designed to meet the specific needs of each construction site, accounting for the constraints unique to each project.

Upfront bench testing is a powerful tool that can be used to evaluate the effectiveness and limitations of various treatment technologies, while also optimizing the cost, efficiency, and sustainability of these systems. In this talk, we will showcase two case studies that demonstrate the power of upfront bench testing in optimizing full-scale groundwater treatment:

1. The first case study involves a site in the Greater Toronto Area (GTA) that required treatment of very high levels of dissolved manganese. Ion exchange backwash into municipal sewers was not an option, making bench testing a crucial tool in finding an effective solution.
2. The second case study is also based in the GTA and required treatment of a unique mix of dissolved metals to meet very stringent storm standards.

We will share valuable insights and lessons learned from leveraging upfront bench testing to optimize treatment system cost, efficiency, and sustainability for construction sites. Attendees will gain a deeper understanding of how bench testing can help overcome site-specific constraints and regulatory requirements, enabling the successful implementation of treatment systems for construction projects.

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Nathan Lichti

Mr. Lichti, B.A.Sc, is an Environmental Engineer at Vertex Environmental Inc. and has designed and implemented more than 200 groundwater treatment programs over the past two decades, including construction dewatering and treatment systems, multi-phase extraction, and in-situ remediation systems at sites across Canada. Mr. Lichti has experience treating metals, chlorinated solvents and petroleum hydrocarbons in a variety of geological settings including overburden and bedrock sites. Mr. Lichti holds a Bachelor's degree in Engineering from the University of Waterloo, and is a Professional Engineer in Ontario.

Mahshid Jannati

Ms. Jannati is groundwater treatment specialist at Vertex Environmental Inc. and has completed numerous laboratory bench tests for the design of construction groundwater treatment systems. Ms. Jannati holds a Master's degree from McMaster University with a focus on water treatment via bioelectrochemical and ion exchange treatment technologies.

Combined ISCO/ISS and other Environmental Soil Mixing Applications: Case Study

Nathan Coughenour, Canada Geo-Solutions
Hubert Guimont, Menard Canada

In 2021, Geo-Solutions Inc. (GSI) successfully completed the remediation of BTEX and chlorobenzene impacted soils using combined in-situ solidification/stabilization (ISS) and in-situ chemical oxidation (ISCO) via soil mixing methods in Eastern United States. In total, 9,600 cubic meters of impacted clayey soils were stabilized over an area of 550 square meters from existing grade to bedrock with an average depth of 17.7 meters.

Several factors lead to ISS/ISCO via soil-mixing being selected as the preferred remedial method including the target treatment depth and the soil type. The treatment depth of over 17m made removal for ex-situ treatment or disposal impractical and the clayey soils made other in-situ remedies such as ISCO via probing or injection points less effective. The combined ISCO/ISS was completed using Alkaline activated Klozur® sodium persulfate (SPS) and Portland cement (PC). The resulting mix resulted in a stabilized monolith with a reduced contaminant mass concentration, reduced permeability, reduced overall flux, and increased strength making it a robust remedial method.

While this approach has become increasingly more common in the US to treat difficult sites, this and other environmental soil mixing applications are still not commonly applied in Canada. This presentation provides details and lessons learned from the implementation of the combined ISCO/ISS approach on the subject project as well as other environmental soil mixing applications with hopes to increase the awareness and use of environmental soil mixing in Canada.

Nathan Coughenour

Nathan Coughenour, P.E. earned a B.S. in Civil Engineering from Bucknell University followed by a Master's in Engineering Management from Ohio University. He has worked for Geo-Solutions, Inc. for the past 9 years and specializes in geotechnical / geoenvironmental construction techniques including slurry walls, soil mixing, and grouting. His project experience includes projects located throughout Canada, The US, and internationally.He has co-authored several publications and articles on various types of geotechnical techniques including the applications and performance of self-hardening slurries, stabilization of coal combustion residuals, and slurry cutoff wall longevity.

Hubert Guimont

Mr. Hubert Guimont, P.Eng, has over 15 years of experience in the geotechnical and environmental fields. He has developed significant expertise in the field of the design of containment works (cut-off walls, dikes and dams, tailings ponds), soil improvement techniques (Controlled Modulus Columns, Deep soil mixing, vertical drains, vibro-replacement, compaction grouting), dredging and sediment management. As the leader on many projects, he is actively involved in all stages from the development of the working method, to detailed design and support during the execution of the works. As technical director and Vice-President for Menard Canada, Mr. Guimont is responsible for coordinating the engineering team across the country.

In-Situ & Ex-Situ Remediation of cVOC Impacts in Conjunction with Site Construction Activities: Challenges and Perspectives from the Landowner, Remedial Contractor and Environmental Consultant

Jaka Suryana, Stantec Consulting Ltd.
Albert Ho, First Capital REIT
Oskar Pula, TRIUM Environmental Inc.

In 2010, Stantec was retained by First Capital (the Landowner) to initiate an investigation related to chlorinated volatile organic compound (cVOC) impacts in soil and groundwater associated with a former dry-cleaning operation in one of the commercial retail units within a shopping plaza building in Alberta. Between 2010 and 2020, numerous assessments of soil, groundwater, soil vapour and indoor air quality were completed at the site. Soil and groundwater tetrachloroethene (PCE) concentrations of up to 1,330 mg/kg and 223,000 µg/L, respectively, were identified to be present within the source area; beneath the former dry cleaner unit. PCE impact concentrations exceeding the referenced guidelines were identified to extend vertically up to a depth of approximately 9 m BGS. A vapour intrusion mitigation system was installed at the site and commenced full-time operation in 2017 since indoor air PCE concentrations exceeding the indoor air quality guidelines were measured within select tenant units in the site building. A risk management plan was also developed in 2020 for the site.

In April 2021, an overnight fire destroyed the shopping plaza building. Through this unfortunate incident, First Capital saw an environmental opportunity to remediate the subsurface cVOC impacts within the source area. TRIUM Environmental was contracted by First Capital and developed a remedial approach involving In-Situ Chemical Reduction (ISCR) and a combined source soil excavation and Ex-Situ Chemical Reduction (EXCR) approaches. ISCR was completed via direct injection of EHC®-L reagent and KB-1® Bioaugmentation product to treat soil and groundwater within the unexcavated areas from the surface depths and to treat groundwater below the source excavation area from the depth of the excavation floor. EXCR was done by incorporating Daramend® anaerobic bioremediation reagent product into the soils at the base of the source excavation. A groundwater treatment/circulation system was also installed within the excavated area to allow for future bioremediation support and groundwater polishing. An impermeable liner was placed on the base of the excavation and the excavation was backfilled using fillcrete, as per geotechnical requirement.

This presentation will provide the unique perspective of the Landowner (client), consultant, and remedial contractor by discussing the challenges during the remediation program which was undertaken in conjunction with the site construction activities between late 2021 and mid-2022. The presentation will provide an overview of challenges posed to the Landowner (environmental vs construction costs, tight construction deadline, insurance requirements, etc.); to the remedial contractor (working around construction activities, incorporating the construction design into the remedial activities, etc.); and to the environmental consultant (re-evaluation of the excavation extent, re-installing the monitoring well network damaged by the construction, navigating provincial guideline changes, etc.). Preliminary results of the remediation program will also be discussed.

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Jaka Suryana

Mr. Suryana, P.Eng., is an Associate with Stantec's Environmental Services for over 10 years, specializing in remediation and revitalization projects. He is a Professional Engineer with provincial registrations in Alberta and Ontario. Mr. Suryana has completed a wide range of site investigation and remediation projects, focusing on contaminated sites within urban areas. He has also managed various projects involving real estate transactions and insurance due diligence works through supports in environmental, geotechnical, property condition assessment, etc. Mr. Suryana has managed 60+ project sites in Alberta remotely from Kingston, Ontario since 2016. He is also currently serving as a Citizen Appointee for the City of Kingston Environmental Advisory Forum for the period of 2023-2026.

Albert Ho

Albert Ho, M.Eng., P.Eng, MBA, CRM, is the Senior Director, Environmental Programs with First Capital REIT for 10 years. He provides direction and leadership to manage environmental risk nationally. Albert has over 20 years of experience in the field of environmental risk management, investigation and remediation. His experience includes both working as an environmental consultant and working in industry including real estate and manufacturing. Albert enjoys learning and is very open to new ideas. He is also a Sessional Lecturer for the Graduate Department of Physical & Environmental Sciences at University of Toronto Scarborough teaching Contaminated Sites Remediation to students of the Master of Environmental Science Program.

Oskar Pula

Mr. Oskar Pula, M.Sc., PAg. is the Vice President, Operations at TRIUM Environmental Inc. He has over 13 years of environmental industry related experience conducting assessment and remediation programs at Oil and Gas and Brownfield sites across Western Canada. Mr. Pula's remediation expertise includes the design, management, and execution of projects and initiatives related to alternative and conventional remediation, research and development of proprietary/ patented technologies, and overall operations management within TRIUM.

Pilot Scale In Situ Treatment of Chlorinated Solvent Source Zone – use of Compound-Specific Isotope Analysis (CSIA) to Assess Treatment Performance and Injection Design.

Daniel Bouchard, GHD
Tyson Fulmer, Catalyst Env Solutions
David Alden, Tersus Environmental

A pilot scale study was conducted to evaluate an in situ reduction strategy that combined both biological processes and abiotic pathways to address a chlorinated solvent (CS) source zone. A zero-valent iron (ZVI) colloidal suspension composed of ZVI particles in glycerol and dispersants was co-injected with a water-mixable vegetable oil based organic substrate. Direct push injection method was used to deliver the amendments to pre-determined depths in the contaminated silt unit, which was overlying an uncontaminated sandy unit.

To assess treatment performance and injection design, compound-specific isotope analysis (CSIA) method was applied to trichloroethene (TCE), cis-dichloroethene (cis-DCE) and vinyl chloride (VC). The application of CSIA was threefold. First, to demonstrate establishment of mass destruction process (biotic or abiotic) by tracking the change of carbon isotopic composition ($\delta^{13}C$) although the co-occurrence of dilution process. Second, to demonstrate full dichlorination of the CS. Finally, to evaluate whether the direct push approach would result in a downward CS mass displacement, CSIA was additionally used as a fingerprint method. Protection of the permeable sand unit lying below the less permeable silt unit containing the CS mass was a prerequisite for full scale ISCO application. Monitoring for CS concentration and $\delta^{13}C$ was performed through monitoring wells with screen portion located either within the silt or the sand unit. A baseline and 3 post-injection sampling events were carried out. The results showed positive isotopic shifts up to 5‰ and 7‰ for TCE and cis-DCE respectively, confirming that injected products effectively degraded those two chlorinated compounds. In contrast, while VC was found to be produced (concentration increase), negative isotopic shifts up to 15‰ was measured. Such concentration-isotope pattern strongly suggests a VC stall in the aquifer. However, the isotopic mass balance nevertheless suggests full dechlorination process, which might be attributed to b-elimination of TCE (via ZVI) rather than VC biodegradation.

Furthermore, $\delta^{13}C$ for TCE in the sand sub-unit also showed more positive values combined with a decrease in concentration following the injection event. This concentration-isotope pattern suggests that no TCE was pushed down into the sand unit during the injection process, but rather an treatment-impacted TCE mass leaking down to the sand aquifer at the silt-sand interface. This presentation will share the results of the pilot test, with a CSIA-oriented result discussion.

Daniel Bouchard

Daniel Bouchard, PhD, began his career in the environmental field in 2001 and has been involved with the CSIA method since 2003. He contributed to the CSIA method development by carrying out Ph.D. studies and post-doctoral studies at the University of Neuchatel, Switzerland. He is currently a Technical Director for in-situ remediation and hydrogeology at GHD, where he supports projects by providing specialized technical and scientific advices to better understand origin, behaviour, and environmental fate of contaminants, and by assessing in-situ remediation treatment performance.

LNAPL in Bedrock Case Study: Using Two Consecutive Remediation Approaches, MPE (multi-phase extraction) and Injection of a Carbon-Based Amendment

Daniel Brenner and Iain Walton, Vertex Environmental Inc.

Until recently, LNAPL remediation in fractured bedrock was a very challenging task with a low probability of success. Variable fracture networks and contaminant back diffusion from the rock matrix combined with a lack of appropriate remediation technologies, frustrated consultants, contractors, and stakeholders alike. However, with each passing year, new remedial techniques and strategies are developed. The purpose of this talk is to present a case study showcasing a treatment train approach employing an 'old' remediation technology followed by the use of a 'new' remediation technology to successfully remediate a complex LNAPL bedrock site.

A desirable waterfront property containing deteriorating infrastructure was in desperate need of revitalization. This site had a history of LNAPL contamination, which posed environmental and public health risks. To remediate the site, a combination of two proven remedial technologies were employed: Multi-Phase Extraction (MPE) and In-Situ Injections using innovative Carbon-Based Amendments. The MPE method was utilized to remove bulk free-phase LNAPL. In-situ injection using new drilling approaches to facilitate surgical amendment delivery within the fractured bedrock was used to treat the residual LNAPL mass rapidly. The combined approach proved to be highly effective, resulting in a significant reduction in LNAPL to levels appropriate to facilitate a risk assessment for future redevelopment of the property. The use of these two technologies in combination allowed for a more comprehensive approach to remediation.
The successful remediation of this site demonstrates the effectiveness of combining remedial technologies to achieve optimal outcomes at sites even with high contaminant levels and tricky geology.

Daniel Brenner

Mr. Brenner, B.Eng., P.Eng., is a Project Manager at Vertex Environmental Inc. with experience in environmental engineering, specializing in site assessment and remediation. Mr. Brenner has been involved in the design and implementation of remediation programs across Canada involving permeable reactive barriers, adsorptive technologies, in-situ chemical oxidation and reduction, aerobic and anaerobic biodegradation, etc. in soil, groundwater, and bedrock for a variety of contaminants, including petroleum hydrocarbons, chlorinated solvents, and heavy metals. He holds a Bachelor's degree in Engineering from the University of Guelph and is a Professional Engineer.

Iain Walton

Mr. Walton, B.Sc. Env, G.Dip.Env., is a Project Manager at Vertex Environmental Inc. with over 9 years of experience in the environmental industry. Mr. Walton has designed and implemented more than 100 remediation programs using pump and treat, multi-phase extraction, air sparge and dewatering systems for a variety of contaminants such as heavy metals, petroleum hydrocarbons, and chlorinated solvents. Mr. Walton holds a Bachelor's degree in environmental science from the University of Guelph.

Residential Redevelopment of a Former Multi-Well Pad and Battery Site Within an Urban Environment

Sylvain Bordenave and John Forbes, Trace Associates Inc.

Trace Associates Inc. (Trace) is presenting on a case study regarding environmental site assessments (ESA), remediation, and facilitation of a timely Reclamation Certificate on a former multi-well pad and battery site within an urban environment. The site was remediated with the objective of being redeveloped into residential/parkland land use. A land development application was in progress, and the stakeholders (developer, operator, and municipality) required the work to be completed in a timely manner to progress the development application. Development was encroaching near the lease.

Multiple ESAs (Phase I and II ESAs and groundwater monitoring programs) were conducted at the Site between 2011 and 2015 by other consultants to evaluate potential soil and groundwater impacts related to former wellsite activities. Four areas of potential environmental concern (APECs) were identified including three wellheads, several process buildings, a flare pit, a drilling waste disposal area, and above-ground storage tanks (AST). All above-ground and below-ground infrastructure from within the lease boundaries were removed or abandoned in 2020. Trace conducted a supplemental Phase 2 ESA in 2021 with the objective of delineating exceedances of petroleum hydrocarbons (PHCs), metals, and salinity parameters in soil. The volume of impacted soil at the site was estimated to be 18,700 m^3.

Following the ESA activities, risk assessment was conducted using a screening level risk assessment (SLRA) approach and led to the development of site-specific remediation objectives for PHCs (Tier 2 pathway exclusion and modification) and salinity parameters in subsoil (Tier 2B Subsoil Salinity Tool [SST]). The SLRA and Tier 2 PHC guidelines development was conducted by Intrinsik and focused on development of Tier 2 soil quality guidelines for the vapour inhalation and drinking water pathway. Tier 2B SST guidelines were developed by Trace.

To refine the results of the SLRA before remediation activities were initiated, a soil vapour assessment was conducted in 2021 by Trace. The objective of the soil vapour assessment was to determine if the volatile PHC concentrations in soil vapour in the former AST area presented a risk for humans through the indoor vapour inhalation pathway as related to future residential development with basements.

The remediation activities were conducted in Fall 2021 through excavation to Tier 2 PHC and Tier 2B SST guidelines. Model input assumptions initially made as part of 2021 Tier 2B SST guidelines derivation did not coincide with actual conditions encountered during the remedial efforts. Additional data collected during the remedial activities and backfill sampling results were utilized to update the Tier 2B SST guidelines. Approximately 6,500 m3 of soil was excavated and transported off site, and a Reclamation Certificate application was submitted in February 2022.

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Sylvain Bordenave

Dr. Sylvain Bordenave is a Principal Risk Assessor and Practice Area Lead for Remediation and Risk with Trace Associates Inc. Sylvain has over 15 years of experience in environmental sciences. At Trace, Sylvain provides senior technical guidance for complex projects, assists the Director of Quality with technical standards, and mentors and trains staff. Sylvain's core competencies include contaminated site management, environmental site assessments, soil vapour assessments, and human health and ecological risk assessments. Sylvain's experience has included projects for a variety of contaminated sites within Western Canada, including commercial/industrial sites, urban sites, and upstream and midstream oil and gas facilities.

John Forbes

John Forbes is an Environmental Scientist and Project Manager with Trace Associates Inc. (Trace). John manages a wide variety of projects for clients in the upstream and midstream oil and gas industry, real estate and development, government, and other industrial sectors. John also completes proposals and cost estimates for clients, conducts complex environmental site assessments (ESAs), soil and groundwater monitoring and sampling, soil and groundwater remediation, hazardous building materials assessments, data evaluation, technical report writing, and is responsible for mentoring and training junior staff. John is also a certified subsoil salinity tool (SST) practitioner and completes complex salinity assessments for clients in all sectors.

SEAR Combined With MPE To Resolved Recalcitrant NAPL At Coal Tar Brownfield Site

George Ivey, Ivey International Inc.

Background and Objective: The former Bacchus Marsh gasworks (Ca. 1889 to 1973) is located within a wide alluvial plain of the Werribee River, Victoria, Australia. Shallow groundwater on the alluvial plain occurs in an upper alluvial aquifer and is highly utilized for irrigation and rationed through the auctioning of water shares. The presence of coal tar NAPL (and associated dissolved phase groundwater impacts) emanating from former gasholders and tar and liquor disposal wells into the upper alluvial aquifer impinges further on upper alluvial aquifer utilization. This presentation focusses on remediation of two coal tar NAPL plumes that was conducted in-situ attempting to meet Victorian EPA and client sustainability goals.

Methodology: After extensive review of possible sustainable remediation options, surfactant enhanced aquifer remediation (SEAR) was selected to address the coal tar NAPL in the aquifer at the site. The surfactant selected was a non-ionic surfactant engineered to dissolve long-chain petroleum hydrocarbons. The surfactant was used in a variety of push-pull and recirculation methods to enhance coal tar recovery. The majority of coal tar NAPL was slightly denser than water (1.03 SG), had low viscosity at 15 degrees Celsius and rested within the poorly sorted clayey, sandy gravel lenses of the upper alluvial aquifer. After initial push-pull applications of SEAR, recirculation was established between the injection well, and an average of three (3) extraction wells. Approximately seven (7) different injection wells were utilized in each of the two (2) coal tar NAPL plumes.

Results: The mobilized NAPL and mico-emulsified hydrocarbons (below CMC) were removed using multiphase extraction (MPE) technologies. Wastewater was treated on-site and reinjected under permit from the regulatory agency to the extent that was practicable. Reinjection of the water was conducted in a manner to optimize the surfactant plume behavior while it was being extracted.

SEAR remedial efforts are ongoing and have resulted in the extraction of coal tar LNAPL and DNAPL, while extracting dissolved contaminants (benzene, naphthalene, ammonia, cyanide) on to activated carbon and resin filters. Most extracted groundwater was returned to maintain/restore aquifer capacity, thereby meeting the EPA's and the client's sustainability goals.

Conclusion: SEAR is a viable method of groundwater remediation to reduce recalcitrant hydrocarbon and chlorinated solvent mass, and decrease overall plume lifespan in unconsolidated aquifers in ~120 days, to achieve site closure.

George (Bud) Ivey

George (Bud) Ivey, B.Sc., CES, CESA, P.Chem, EP is the President and Senior Remediation Specialist with Ivey International Inc. He is an environmental professional with over thirty years of international assessment and remediation experience. He has worked on more than 3000 major environmental remediation projects, which have taken him to over 50 countries globally. He has more than 20 international patents and trademarks, and is the recipient of several prestigious international environmental awards. His educational background includes: Synthetic-Organic Chemistry, Geological Engineering, and a Master's Certification in Project Management.

Significant Return on Investment Achieved by Successfully Remediating a Challenging Chlorinated Solvent Site

Kevin French, Vertex Environmental Inc.

Tetrachloroethylene (PCE) and related degradation products were identified in soil, groundwater and soil vapour at a shopping center in British Columbia at concentrations above the BC CSR standards both on-site and off-site beneath sensitive receptors including residential properties and a school.

Prior to remediation, PCE concentrations in groundwater greater than 10% of its solubility and therefore indicative of the potential presence of dense, non-aqueous phase liquid (DNAPL) resulting in the site being classified as "High Risk". This made it unavailable for redevelopment and essentially unmarketable for sale by the site owners. A highly effective remedial approach was needed to realize the otherwise inherent value of the real estate asset.

A pilot-scale remediation program was completed in the worst-case area at the site in June 2019. Verification monitoring completed over the subsequent year showed that PCE concentrations in groundwater had dropped to the point that the "High Risk" designation of the site could be removed. This also enabled the owners to apply for upzoning of the site to set the stage for future redevelopment to a higher and better use.

In September 2021, after completion of the full-scale on- and off-site remediation program, a perimeter groundwater pumping and treatment system operating at the site was able to be shut down, eliminating the need for on-going operation, maintenance and monitoring activities.

There is now over an additional year of post-remediation quarterly groundwater sampling results available for the Site demonstrating that the groundwater plume has significantly decreased in size and is now considered stable. The consultant is in the process of completing a risk assessment and applying for risk-based Certificates of Compliance for the property.

Site conditions have improved to the point where it will now be possible to redevelop the site for mixed commercial and residential use. The site owners now have a marketable asset whose increase in property value is worth considerably more than the cost of the entire remediation program and are looking forward to what the site can become without the previous significant restrictions on land use.

This case study is an excellent example of how applying an effective remediation approach can turn a highly contaminated site into a fully productive property and result in a significant return on the remedial investment.

Kevin French

Kevin French, B.A.Sc., P.Eng. is Vice President of Vertex Environmental and has over 35 years of experience and expertise in environmental engineering, specializing in site characterization and remediation. He has been involved in the design and implementation of remediation programs across Canada involving permeable reactive barriers, adsorptive and stabilization technologies, in-situ chemical oxidation and reduction, aerobic and anaerobic biodegradation, etc. in soil, groundwater and fractured bedrock for a variety of contaminants, including PFAS, petroleum hydrocarbons, chlorinated solvents, heavy metals, soil sterilants and other compounds. Kevin holds a Bachelors' degree in Engineering from the University of Waterloo and is a Professional Engineer and a Qualified Person in Ontario.

Windermere Wetland: a History of Contamination, Remediation, Restoration, Innovative Monitoring and Management

Gordon Wichert, SLR Consulting

Prior to 2010, Windermere Basin served as a sediment trap at the mouth of Red Hill Creek, discharging to Hamilton Harbour. The City of Hamilton, supported by a stakeholder committee, established objectives for restoration: maintain navigation, improve environmental quality, create recreational opportunities, improve landscape aesthetics, and improve habitat for aquatic and terrestrial species. A risk assessment was undertaken, which addressed ecological and human health. As a result of the risk assessment the project site was the subject of remediation through capping, but the sediments were unchanged. Additional components included stakeholder meetings, a design charette, engineering design, and construction. New habitat concepts and opportunities resulted from stakeholder meetings and the design charette. By isolating and draining the aquatic environment, we were able to sculpt new terrestrial and aquatic habitat opportunities. A fishway was constructed with grates to exclude adult Common Carp, an invasive species. Although a few fish species were introduced to the new wetland by the Ministry of Natural Resources and Forestry (MNRF), the fishway was operated to encourage natural recolonization by local fish species. This presentation will chart the history of remediating negative effects associated with contaminated sediments, construction and re-establishment of species in the wetland. Complementary conventional and innovative monitoring approaches were applied to gather the information to assess the effectiveness of remediation, habitat design and wetland function. A summary of lessons learned over the past 15 years with respect to wetland remediation, implementation of habitat restoration plans, invasive species monitoring, and wetland management will conclude the talk.

Gordon Wichert

Gordon Wichert, Ph.D., holds the position of Technical Director –Ecology at SLR Consulting (SLR). He has worked as a biologist for over 25 years. Prior to joining SLR, Gordon worked in government, academia and international development. He has completed studies in conservation ecology, watershed planning, landscape-scale delineation and classification, and environmental effects monitoring, and land development. Much of his work involves characterizing existing ecosystem conditions, identifying potential responses to proposed land use changes often associated with development, developing environmental management plans for construction and recommending mitigation and rehabilitation measures.

CER Reported Contaminated Sites and Remediation Operating Practices Update

Holly Kingston and Adele Houston, Canada Energy Regulator

The Canada Energy Regulator (CER) regulates inter-provincial and international pipelines, international power lines, offshore renewables, the export and import of energy, and tolls and tariffs, as well as oil and gas activities on frontier lands. The CER's remediation process applies Canada-wide to contaminated sites that are reported to the CER from project construction through to abandonment, including both confirmed historical contamination and contamination caused during incidents reported to the CER. The CER's 2020 Remediation Process Guide provides the framework for companies to demonstrate they are effectively anticipating, preventing, managing and mitigating adverse effects of contamination related to their facilities. This presentation will include background on the regulatory context and requirements of the remediation process, present data summarizing contaminated sites reported to the CER and provide updates including the public posting of Notices of Contamination and annual updates submitted since August 2018, and addendums to the Remediation Process Guide now posted on the CER webpage.

Holly Kingston

Holly Kingston, M.Sc., P.Geo., is the acting Director for Environmental Protection within the Field Operations Oversight business unit of the Canada Energy Regulator (CER). She holds a degree in Earth Sciences with a specialization in Geochemistry and a Master degree in Soil Science – Microbiology. Holly has worked in the contaminated sites industry since 2008. She started as an environmental consultant, working in BC, Ontario, Alberta, and Saskatchewan characterizing contaminated sites and conducting risk assessments. In 2016, she joined the CER and has been happily working as an Inspection Officer with a focus on oversight of contaminated site remediation and risk management in the pipeline and powerline industries ever since.

Adele Houston

Adele Houston, M.Sc., P.Biol, is a Technical Leader in the Environmental Protection team within the Field Operations Oversight business unit at the Canada Energy Regulator (CER). After working as a risk assessment specialist for 18 years, she joined the CER in 2020 becoming part of the CER's remediation process working group and providing oversight for the remediation and risk management of contaminated sites.

Federal Contaminated Sites Action Plan Demand Forecast 2023-2028

Claudia Beauchemin and Brad Simpson, Public Services and Procurement Canada

The Federal Contaminated Sites Action Plan (FCSAP) is a government-wide program co-led by Environment and Climate Change Canada and Treasury Board of Canada Secretariat, to reduce risks to human health and the environment and associated financial liabilities. In Budget 2019, the FCSAP was renewed with funding of$1.2 billion from 2020-2024 along with another $2.2 billion from 2020-2034 for the new Northern Abandoned Mines Reclamation Program (NAMRP). This presentation will provide an overview of the federal contaminated sites related programs in Ontario and Atlantic Canada, the current forecasts for private sector support starting April 1, 2023, with a focus on remediation funding, and the various procurement approaches, including ways to encourage participation of Indigenous companies and small and medium sized enterprises (SMEs).

Claudia Beauchemin

Claudia Beauchemin works in the Green and Sustainable Government Directorate of Public Services and Procurement Canada (PSPC) as the Contaminated Sites Program Manager. She has more than 25 years of experience in the management of contaminated sites. She graduated from École Polytechnique de Montréal in 1995 and worked in the private sector for engineering consulting firms before joining the public service, at PSPC, in 2008. Her team is responsible for the management of the FCSAP program at PSPC (program management, governance operations, planning and reporting) in addition to its role of expert support to the program by developing tools for managing contaminated sites, training and supporting custodians in the delivery of their own program under FCSAP.

Brad Simpson

Mr. Brad Simpson is the Manager of Risk Assessments within Public Services and Procurement Canada's (PSPC) Environmental Services and Contaminated Site Directorate in Ontario Region, based in Toronto. Brad has managed numerous risk assessment, remediation and environmental site assessments projects for PSPC and other federal government custodians, in accordance with federal contaminated sites guidance documents and policies and several risk assessments in accordance with provincial regulations. Brad holds a B.Sc. in Chemistry and Environmental Science from the University of Western Ontario. Brad currently co-chairs the Ontario Regional Implementation Planning Board under FCSAP. Prior to managing PSPC's risk assessment group, Brad managed PSPC's Special Projects group focused on assessing low level radioactive waste as part of the Port Hope Area Initiative. He began his contaminated sites career completing Phase II ESAs for Ontario Hydro and prior to working on federal contaminated sites at PSPC, Brad was a Senior Enforcement Officer and designated Fisheries Officer for Environment and Climate Change Canada.

Newton's Pendulum: The Swinging Spheres of Environmental Law

Jacquelyn Stevens, John Georgakopoulos, Matthew Gardner and Anand Srivastava, Willms & Shier Environmental Lawyers LLP

Environmental law in 2022 resembled Newton's Pendulum – the proverbial environmental legal swinging spheres showed conservation of momentum, conservation of energy, and even some friction.

Part 1 - Civil and regulatory litigation continued to drive the key elements of environmental law, including reinforcing traditional environmental causes of action, advancing the polluter pays principle and providing unique, and at times, expansive remedies.

Part 2 - Governments moved forward with the development of and amendments to key environmental laws including legislation requiring net-zero targets, banning of single use plastics, regulating PFAS, managing the movement and re-use of soil, and building more homes faster.

During this two-part presentation, Jacquelyn Stevens, John Georgakopoulos, Matthew Gardner, and Anand Srivastava will provide highlights and key takeaways from 2022 and provide their thoughts about environmental risks and liabilities as the pendulum continues to swing.

Jacquelyn Stevens

Jacquelyn Stevens B.Sc. (Hons.), M.Sc., M.S.E.L., LL.B., is a Partner at Willms & Shier Environmental Lawyers LLP and is a Certified Specialist in Environmental Law by the Law Society of Ontario. Jacquie has significant expertise representing a wide range of clients in environmental civil litigation, defence of prosecutions by environmental regulators, and at administrative appeals and hearings. Jacquie also provides effective advice and solutions for environmental due diligence and compliance, brownfields/contaminated site remediation, and environmental approvals for air, odour, noise and waste. Jacquie advises on cross-boundary migration of contamination and remediation options and has significant expertise involving contamination issues at dry cleaning operations and gas stations. Jacquie is called to the Bar in Alberta and Ontario.

O. Reg. 406/19 On-Site and Excess Soil Management: Procurement and Contract Best Management Practices

Jenna Allan and David Wong, EnVision Consultants Ltd.

With Ontario Regulation 406/19 for On-Site and Excess Soil Management now fully in effect, there is an increased need to ensure the regulatory requirements are clearly and effectively communicated in tender documents and associated contracts.

EnVision is at the forefront of delivering O. Reg. 406/19 services to public and private clients across Ontario, providing comprehensive, practical deliverables that provide clear direction with respect to beneficial re-use and/or disposal options for excess soils. EnVision has assisted public and private clients with evaluating and solving challenges associated with the new regulation as they emerge, not only with addressing the changes with regards to how excess soils generated in association with infrastructure, maintenance, and development projects are managed under the new regulation, but also with effective procurement and contract set-up.

This presentation focuses on:

- Effective planning for excess soil management projects from the perspective of the Project Leader, Qualified Person, and Contractor
- Recommendations and best management practices for tender documents & contracts
- Early lessons learned to avoid potential contract issues

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Jenna Allan

Jenna Allan, P.Eng., QPESA, PMP is an Environmental Engineer, licensed in the Province of Ontario, holding the position of Director, Environment with EnVision Consultants Ltd. Jenna has obtained a Master of Engineering Science Degree in Green and Environmental Engineering and has been involved in numerous Excess Soil management projects, ranging from linear infrastructure projects to residential redevelopment of industrial/commercial properties. Through presentations, consultation, and the development of resources and guidance documents, Jenna uses her technical skills to assist clients in navigating O. Reg. 406/19 related challenges.

Jenna also possesses extensive experience in regulatory and due-diligence Phase One and Phase Two Environmental Site Assessments, soil and groundwater remediation, Risk Assessment, Record of Site Condition, Certificate of Property Use management, and land conveyances. Jenna is a Qualified Person under O. Reg. 153/04 and O. Reg. 406/19.

David Wong

Dave is the Site Assessment and Remediation Lead at EnVision Consults Ltd, with 20 years of experience in the environmental consulting industry. He provides consulting services relating to the assessment and remediation/management of contaminated soil and groundwater. Dave has been involved in managed environmental projects across Canada and possesses extensive experience in Environmental Peer Reviews, Soil and Groundwater Remediation Technologies, People and Project Management, Risk Assessment, Record of Site Conditions (RSCs), Certificate of Property Use (CPU) management, and land conveyance projects. His experience includes managing and conducting Phase II ESAs, monitoring programs, contract administration, remediation/construction projects, development of remedial action plans, remedial technology evaluations, petroleum system compliance, and environmental and technical peer reviews. In addition, his area of practice include remediation systems, having designed or assisted in designing, implemented, optimized, and constructed several remedial treatment systems involving soil vapour extraction, high vacuum multi-phase extraction, pneumatic LNAPL recovery, air sparging, bio-slurping, sub-slab depressurization systems, soil containment, as well as chemical injections. David has a Bachelor of Applied Science Degree in Civil Engineering (Environmental Engineering and Water Resources Option) from the University of Waterloo and is a licensed Engineer and designated “Consulting Engineer” in the Province of Ontario. David is a Qualified Person (QPESA) under O. Reg. 153/04 and O. Reg. 406/19.

Plant Uptake of Petroleum Hydrocarbons and Trace Metals and Derivation of Soil-to-Plant Uptake Factors: Advancing the Science of Environmental Risk Assessment

Erik Martin, Vertex Resource Group Ltd.; Gwen O'Sullivan, Mount Royal University and Court Sandau, Chemistry Matters Inc.

Environmental Risk Assessment (ERA) is a specialized tool that can be used for management of contaminated sites. Depending on the outcome of the ERA, regulatory closure can be obtained or some form of risk management and/or remediation is required. Not all components of the ERA process are well-characterized, and when there is uncertainty in ERA it is necessary to use conservative assumptions to ensure protection of human and ecological health. These assumptions can add up, causing the findings of the ERA to be somewhat questionable. Therefore, any opportunity to refine the ERA process and make it more accurate should be investigated.

One exposure pathway that oftentimes introduces uncertainty into the ERA process is ingestion of vegetation by humans and ecological receptors. Notably, First Nations and many wildlife species are known to ingest wild plants. However, plant analytical data is generally not collected during environmental site assessments and scientists are left to evaluate exposure to contaminants in plants through the use of soil-to-plant uptake factors (UFs; essentially a ratio of contaminant concentration in plants to contaminant concentration in soil). There are very few soil-to-plant UFs available for petroleum hydrocarbons (PHCs), and those available are generally estimated from such parameters as the octanol/water partition coefficient [Kow]) and not empirical data.

Given the information above, we have completed laboratory studies to: 1) determine the extent to which plants, four species in total, uptake PHCs and trace metals, and 2) establish soil-to-plant UFs and models for specific PHC constituents and metals. Plants were cultivated in PHC- and metals-impacted soil and both growth and health parameters were assessed at various time points. Plant tissues and soil were analyzed for trace metals using Inductively Coupled Plasma (ICP) analysis while PHCs were quantified using two-dimensional gas chromatography time of flight mass spectrometry (GCxGC TOF-MS), a novel laboratory instrument that allows individual PHC constituents to be measured at part-per-billion levels. Findings from these studies will be presented and discussed.

Going forward, this data will allow for more accurate assessments of potential health effects for human and ecological receptors from exposure to contaminants in plants. Furthermore, it will no longer be necessary to collect and analyze vegetation samples to accurately evaluate this exposure pathway as soil samples will suffice. This could lead to cost savings for industries with substantial environmental liability such as Oil & Gas, Mining, and Agriculture. The development of soil-to-plant UFs and models for PHCs and trace metals may also have important applications within the fields of reclamation, phytoremediation, biomonitoring, and others.

This work was funded by the Alberta Upstream Petroleum Research Fund (AUPRF), which is managed by Petroleum Technology Alliance Canada (PTAC).

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Erik J. Martin

Dr. Erik J. Martin, Ph.D., D.A.B.T., P.Biol. is a board-certified Toxicologist with Vertex Resource Group Ltd. Dr. Martin's technical expertise includes environmental and mechanistic toxicology, and environmental risk assessment. Dr. Martin leads a team of technical specialists who primarily implement risk-based approaches in management of contaminated sites.

Gwen O'Sullivan

Dr. Gwen O'Sullivan, Ph.D., MRSC is a Professor & Chair of the Department of Earth & Environmental Science at Mount Royal University. Her areas of expertise include environmental chemistry, environmental forensics and contaminated land and groundwater. She has over 15 years of experience in a variety of environmental forensic projects which includes legal sampling, chemical fingerprinting and statistical evaluation of data for source identification of contaminants of concern including persistent organic pollutants, petroleum hydrocarbons, methane, nitrates, and dioxins in water, soils and sediments.

Court D. Sandau

Dr. Court D. Sandau, Ph.D., P.Chem. is the principal and senior chemist at Chemistry Matters Inc. Previously, Dr. Sandau was president of TRIUM Environmental Inc. and a senior lead and laboratory manager at the Centers for Disease Control and Prevention (CDC). Dr. Sandau specializes in expert witness & litigation support; environmental forensics investigations; geoforensics investigations; risk assessment; scientific advisor; biomonitoring studies & data interpretation; data quality/data validation; and arson investigations. Dr. Sandau has written over 100 publications and has given numerous presentations internationally to his peers. Dr. Sandau is respected globally for his expertise and has worked in multiple countries.

Recognizing Natural Source Zone Depletion (NSZD) for a More Sustainable Approach to the Long-Term Management of Residual LNAPL at the CN Gogama Release Site

Matt Rousseau and Dan Murray, GH
Aaron Stadnyk, 3CN

The management of residual light non-aqueous phase liquid (LNAPL) remains a significant long-term challenge at many sites since LNAPL remedial/recovery efforts will often reach practical end-points with a significant fraction of residual LNAPL remaining in the ground. It is now understood that natural LNAPL biodegradation, referred to as natural source zone depletion (NSZD), will be found to be occurring at most LNAPL sites at rates that can rival or exceed what can be achieved via engineered systems in a much more sustainable manner. Furthermore, NSZD can address residual LNAPL that will be largely inaccessible by conventional LNAPL recovery efforts, and will therefore represent the dominant/final LNAPL removal mechanism at many if not most LNAPL sites. The measurement and use of NSZD data is gaining in acceptance and is promoted in recent guidance from the American Petroleum Institute (API – U.S.), the Interstate Technology and Regulatory Council (ITRC – U.S.) in the U.S., and the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC-CARE – Australia) to name a few. Assessing NSZD can serve a number of purposes including:

- Quantifying NSZD as the baseline remedy consideration
- Scrutinizing the costs and benefits of engineered remedies over NSZD
- Supporting line of evidence of the appropriateness of risk-based LNAPL management strategies

This presentation will focus on two techniques used to quantify NSZD (LNAPL degradation) rates:

1. Near surface carbon dioxide (CO2) efflux: As CO2 will represent the final product of LNAPL mineralization, this technique involves measuring surface CO2 efflux at LNAPL sites and using different ways of isolating the fraction of the measured CO2 efflux that is derived from LNAPL degradation (as opposed to modern carbon sources such as plant respiration). This technique can be applied using both active and/or passive techniques.
2. Biogenic heat: Focuses on identifying temperature gradients/anomalies in the vadose zone within an LNAPL-impacted area that are associated with exothermic biodegradation reactions. The associated heat flux and heat of the reaction form the basis for the estimation of the LNAPL degradation/NSZD rate. The specific monitoring strategy will be detailed along with the methodologies used to evaluate the data and develop NSZD rate estimates. Results will be presented using 3D visualization techniques, along with a discussion of other site monitoring data used as complementary lines of evidence of active LNAPL degradation.

The results lend themselves to the growing body of evidence that NSZD rates can be significant, providing comparable or better performance than many engineered/active remedies without the associated environmental footprint or remedial risk. As with the now widely accepted use of monitored natural attenuation (MNA) to remediate dissolved phase petroleum hydrocarbons, the data presented here support the increasing inclusion of NSZD as a fundamental/baseline consideration for the remediation or management of LNAPL.

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Matt Rousseau

Matt Rousseau is a Senior Environmental Engineer and global NAPL Technical Lead with GHD based in Canada. Matt has been consulting for over 20 years, with a focus on sites contaminated with petroleum products and other NAPLs for most of that time. His work centers on the design of site investigation programs and the development of NAPL remediation and management strategies with a focus on sustainable risk-based solutions. Matt regularly provides training related to NAPL site management and has helped develop related technical guidance documents in Canada, the U.S., and Australia. Matt has B.A.Sc. (1997) and M.A.Sc. (2000) degrees in Environmental Engineering from the University of Windsor in Windsor, Ontario, Canada.

Soil Respiration Rates under Natural Attenuation versus Enhanced Biodegradation

Sophia Dore, Donald Pope and Alex Cox, GHD

Groundwater and soil at a petroleum industry site contains benzene, toluene, and total petroleum hydrocarbons in the gasoline range (TPHg). A treatability study was performed to evaluate potential treatment alternatives that had the potential for future application at the Site as part of a planned corrective action for soil and groundwater impacts. Active stimulation of biodegradation was compared to natural attenuation to determine whether active stimulation provided a significant advantage over natural processes.

Natural attenuation is a remedial approach that relies on natural subsurface mechanisms that are classified as either destructive or nondestructive. Biodegradation is the most important in situ destructive mechanism, while non-destructive mechanisms include sorption, dispersion, dilution, and volatilization. However, natural attenuation has its inherent limitations and can be slow, making the time frame for completion relatively long.

Enhanced biodegradation, both aerobic and anaerobic, and natural attenuation were evaluated using groundwater and soil from the Site. Microcosms were prepared using varying doses of different amendments to evaluate enhanced biodegradation for the treatment of benzene, toluene, and TPHg. Amendments tested included, oxygen, nutrients, sulfate and microbial inocula. A second set of microcosms was prepared without the use of any amendments to evaluate the existing natural attenuation occurring at the Site.

Compound-Specific Isotope Analysis (CSIA) was performed on groundwater samples collected from the Site. The results of the CSIA were used to determine whether natural attenuation could be demonstrated to be occurring.

The data suggest that natural attenuation would occur at the Site over time; however, natural attenuation rates would be slow, therefore treatment by natural attenuation would require an extended time period. Low microbial populations currently present in soil would also limit natural attenuation in the vadose zone. Natural attenuation could be applied at the Site if an extended time period was available for monitoring.

Enhanced biodegradation appeared to increase soil respiration at the Site and was expected to increase biodegradation rates over time. More biodegradation of benzene, toluene, and TPHg were observed when aerobic conditions were enhanced than when anaerobic conditions were enhanced; therefore, enhanced aerobic biodegradation wasthe recommended technology, although anaerobic biodegradation would also be effective.

CSIA results showed that samples with higher benzene concentrations had higher $\delta^{13}C$ values. This suggested that biodegradation was occurring at a low rate in the source areas where benzene concentrations were highest but that the lower concentrations outside the source areas were caused by dilution rather than biodegradation and that there was less biodegradation occurring outside the source areas.

No relationship between $\delta^{2}H$ values and benzene concentration was observed, which suggested that biodegradation was primarily occurring by the breakage of carbon-carbon bonds rather than carbon-hydrogen bonds. This is consistent with the known benzene biodegradation pathway.

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Sophia Dore

Sophia is a member of the GHD Innovative Technology Group. She has 20 years of experience in environmental remediation. She assists project managers by providing technical expertise in the areas of biology, chemistry, and remedial design. Sophia also manages the treatability study laboratory and is responsible for designing, conducting, performing data analysis, and reporting on treatability studies including chemical and biological treatments of contaminated soils and waters.

Innovative In-Situ Remediation Approach to Treat PFAS-Impacted Groundwater

Matt Pourabadehei and Robert Timlin, SNC-Lavalin

Aqueous film forming foam (AFFF), utilized for suppressing fires involving petroleum-based products, has been stored, spilled, and used at various military and civilian airports across the country for decades. Our site is a Canadian Forces Base in Ontario, where AFFF was identified as the main source of per-and polyfluoroalkyl substances (PFAS) contamination in soil, groundwater, surface water and sediment. Due to proximity of the site to a significant water body (hydraulically downgradient of impacts), there may be a potential risk of adverse effects to human and the aquatic receptors, therefore an effective remediation approach is required to prevent PFAS-impacted groundwater from discharging to surface water.

There are currently few technically and/or economically feasible remedial options for PFAS-impacted groundwater. Most current active remediation systems for PFAS utilize "pump and treatment", an ex-situ technology. Although pump and treatment systems can be effective in some applications, most require laborious long-term, and perhaps perpetual, operation and maintenance, and they can result in non-uniform remediation. Injection of treatment materials (in a slurry form) is a more-recently developed in-situ remediation technology for PFAS, but the materials only stabilize the PFAS in the injection zone; the PFAS are not removed from the environment. The longevity of these media to stabilize PFAS is uncertain, and if media eventually desorb the PFAS, a secondary contaminant source will arise.

Given the above constraints with current remediation technologies, an innovative pilot scale in-situ remediation technique was developed for the site consisting of an in-situ treatment train (ISTT) in the form of a "funnel and gate" permeable reactive barrier (PRB). The impermeable concrete cut-off funnel walls direct impacted groundwater toward the ISTT-PRB's high permeability treatment gate in a rather conventional approach. However, for the pilot system, the gate structure was constructed with three separate chambers running simultaneously in parallel, and each chamber contains two reactive cells running simultaneously in series. Each lead cell contains modified bentonite clay, and each lag cell contains bituminous granular activated carbon, thus creating treatment trains. The use of multiple types of media enables a wider range of PFAS to be captured than any single media. The lead and lag treatment cells each contain different but specific mixtures of media/sand, and each are monitored separately to enable assessment of the effectiveness of the different concentrations of media to treat the groundwater. The system was designed to permit removal and replacement of the media as they become exhausted, thus physically removing PFAS mass from the site and prolonging the life of the ISTT-PRB.

The pilot scale system's design was completed in summer 2021 and was constructed at the site during the winter of 2022. Monitoring of the system is completed after one year of operation. This presentation will highlight the advantages of this remediation approach and the challenges encountered during the construction, as well as the results of quarterly monitoring and sampling programs, during the 2022-2023 fiscal year.

Matt Pourabadehei

Mr. Matt Pourabadehei, Ph.D., P.Eng. is a senior environmental engineer and project manager with more than twelve years of experience in the assessment and remediation of contaminated sites. His areas of expertise are in phased environmental site assessments, remedial option analysis, and remediation of impacted soil and groundwater. Dr. Pourabadehei is a PFAS technical expert with SNC-Lavalin and has worked on site assessment and remediation projects for PFAS impacted sites in several federally owned locations in Ontario, Yukon, and British Colombia.

Innovative In Situ Solution to Persistent PFAS Groundwater and Soil Contamination

Jean Pare, Chemco Inc

The extensive use of per- and poly-fluoroalkyl substances (PFAS) has led to widespread soil and groundwater contamination that needs to be addressed. Remediation of PFAS-contaminated solid and aqueous media can be extremely challenging due to the high chemical and thermal stability of PFAS compounds in the environment, their unique physicochemical properties (i.e., both hydrophobic and oleophobic behaviors), and their extremely persistent nature (i.e., limited or no biodegradation).

In-situ sorption barriers based on injectable colloidal activated carbon can stop fast advancing PFAS plumes in an effective and sustained manner. A novel material for in situ remediation of PFAS has been developed and validated in both lab and field scale settings by the Helmholtz Environmental Research Center Leipzig (UFZ).

The material is injected directly into the contaminated area through existing monitoring wells, via injection wells or in a direct push process. Due to the micrometer size of the particles, the suspension is optimally distributed, coats the soil matrix and ensures a lasting immobilization of the contaminants due to its highly adsorptive and specially modified surface. The duration of the effect of the established adsorption zone in the aquifer is typically several decades for immobilization of PFAS by in situ sorption barriers.

This novel material was found to be a cost-effective method to quickly and effectively contain mobile plumes of PFAS in groundwater

This presentation will mainly focus on material development and testing of injectable colloidal activated carbon for in-situ sorption barriers to contains contaminant movement from source zone or migrating plume.

Jean Pare

Jean Pare, P.Eng., has a degree in Chemical Engineering from Laval University. He has been involved for the last 25 years in the evaluation, development, design, and promotion of both conventional and innovative environmental technologies. As Vice President with Chemco Inc., his responsibilities include the remediation design, technico-economical analysis and technology supply for chemical oxidation and reduction, soil washing, and enhanced bioremediation. Last year, he worked with over 400 sites applying his expertise to various types of organic and inorganic contaminants in soil and groundwater. He is also involved with many environmental organizations such as CLRA, CBN, ESAA, BCEIA and Reseau-Environnement where he is an active technical committee member and regular technical speaker.

STAR and STARx – A Smouldering Solution to PFAS from Laboratory to Field Scale Application

Laura Kinsman, Gavin Grant, Brian Harrison, David Major,
Joshua Brown and Grant Scholes, Savron
Jason Gerhard, Western University
David Patch and Kela Weber, Royal Military College
Chris McRae and Andrew Tam, Department of National Defence

Per- and polyfluoroalkyl substances (PFAS) have been identified by many regulatory agencies as being compounds of emerging concern within the environment. This large, complex group of compounds can present many challenges for remediation given their chemical/physical properties, resistance to degradation and treatment by conventional approaches, and their rapidly evolving regulatory framework.

Smouldering is a self-sustaining (i.e., energy efficient), flameless form of combustion that can use low volatility, high energy contaminants as the fuel to support their own destruction. This approach is commercially available as the STAR (in situ) and STARx (ex-situ) technologies and has traditionally been used for the treatment of heavy hydrocarbons. Per- and polyfluoroalkyl substances (PFAS) do not support smouldering combustion in and of themselves, and their high thermal stability often requires temperatures greater than 900°C for destruction; however, a supplementary fuel can be used to reach these temperatures in a smouldering combustion reaction to facilitate the destruction of PFAS.

A scale-up study was conducted under the US Department of Defense (DoD) Strategic Environmental Research Program (SERDP) to evaluate the application of ex situ smouldering to treat PFAS-impacted soils and media with the use of low concentrations of granular activated carbon (GAC) as a supplementary fuel. Following rigorous sampling and analysis using both targeted PFAS and particle-induced gamma emission (PIGE) to close the fluorine mass balance at the laboratory scale, a field pilot test was completed at Canadian Forces Base (CFB) Trenton. Results demonstrated reduction of PFAS concentrations in soil to near or below detection limits for tests across all scales. Less than 1% of the total PFAS mass was found in emissions, with the removal of PFAS and fluorinated breakdown products in emissions achieved via vapour phase GAC. When spent, this GAC can be recycled for use as supplementary fuel in subsequent treatment batches.

Two additional projects are currently in progress to further evaluate PFAS smoldering, both ex situ and in situ. The first is in collaboration with the US Air Force to evaluate ex-situ smoldering treatment for a wide range of PFAS-impacted soils (e.g., grain size, moisture contents, PFAS concentrations) and spent materials (e.g., spent ion exchange [IX] resin and spent GAC). The second is a study with the DoD Environmental Security Technology Certification Program

(ESTCP) to evaluate in situ smouldering of PFAS-impacted source zones using colloidal or powder activated carbon (CAC/PAC) applied in conjunction with emulsified vegetable oil (EVO) via soil mixing techniques. Laboratory testing completed to date has demonstrated the ability to achieve necessary destruction temperatures.

This presentation will provide a summary of the results of the ex situ scale up and field pilot testing program, as well as an update on work in progress evaluating in situ smouldering of PFAS.

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Laura Kinsman

Laura Kinsman, M.E.Sc., is a Project Professional at Savron. She completed her M.E.Sc. studies at the University of Western Ontario under the direction of Dr. Jason Gerhard and Dr. Jose Torero – co-inventors of the STAR technology. Ms. Kinsman joined Savron in 2014 and has been actively involved in system design, field operations, and project management at sites across North America and Asia, including pilot testing and full-scale applications of both in situ and ex situ smouldering remediation.

Treating PFAS: Current In-Situ Remediation Approaches

Bruce Tunnicliffe, Vertex Environmental Inc.

Per- and polyfluoroalkyl substances (PFAS) are the latest emerging contaminants to challenge our industry, and as our understanding of this "forever chemical" evolves, new standards are being set. For example, Health Canada and Ontario have introduced drinking water standards for selected PFAS compounds and, most recently, in a document dated January 2023, Alberta released soil and groundwater remediation standards for two of the most studied PFAS compounds: perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).

While new standards are being published, unfortunately there is no consensus as to the most effective PFAS remediation approach. There will be a strong focus on PFAS remediation in 2023 as more standards (and more stringent standards) continue to be developed across Canada, North America and the world.

The purpose of this talk is to summarize the current state of PFAS remediation and introduce a new method for in-situ treatment of PFAS.

Currently the most demonstrated PFAS treatment technologies rely on non-destructive means that remove PFAS from water via adsorption media. Pragmatic in-situ treatment options may currently include sequestration, but the proper selection and application methods of adsorbent materials for immobilization of PFAS in groundwater plumes may be key in the near-term for full-scale, widespread, in-situ PFAS plume treatment.

This presentation will review and present data from multiple studies (bench and field) where adsorbent materials have been utilized to treat PFAS contamination in groundwater. Furthermore, this presentation will discuss the significant efforts being made to optimize and apply these existing adsorptive technologies to enhance their reliability, lifespan, and overall effectiveness in treating PFAS contaminated groundwater plumes. Various in-situ amendment materials will be reviewed, including activated carbon and clay-based materials. Throughout the presentation, recommendations and insights will be offered into the potential for future effective in-situ PFAS treatment methods.

Bruce Tunnicliffe

Mr. Tunnicliffe, M.A.Sc. is President of Vertex Environmental Inc., is an Environmental Engineer, and has over 20 years of experience designing and implementing remediation programs for chlorinated solvents, petroleum hydrocarbons and emerging contaminants such as PFAS/PFOA. Mr. Tunnicliffe holds a Master's degree from the University of Waterloo where he studied chemical oxidation in fractured bedrock.

Dewatering and Containment of Heavy Metal Contaminated Sediments with Geotextile Containers and Polymers. Developing and Validating System Performance and Design.

Kevin Bossy, Tyler Anderson and Tony Kobilnyk, Bishop Water

Processing and refining operations at former mine site in Eastern Canada resulted in significant environmental impact, including residual concentrations of arsenic, cobalt, copper, nickel and low-level radioactive material in soil, sediment, surface and groundwater. Part of the cleanup focused on developing an efficient and effective way to collect and dewater contaminated sediments from an adjacent watercourse.

This paper presents the methods, equipment and results from a project to develop and validate a hydraulic process to remove and reliably contain contaminated sediments in a manner that reduced the handling of material during the clean up effort. The design incorporated dredging, geotextile containment and filtration, polymer conditioning, pH adjustment and filtrate management.

Geotextile containers offer a reliable, cost-effective technology to collect, dewater and permanently store contaminated sediment at or near the site. This process has been used worldwide for environmental remediation projects at many active and decommissioned industrial and commercial sites.

The use of specially selected polymers enables a high level of dewaterability and can improve the retention of heavy metals and other contaminants. The combination of polymer and the filtration provided by the woven geotextile can produce filtrate that is low in total suspended solids and is ideal as a pretreatment step prior to discharge to an onsite or central wastewater facility. In some cases, the filtrate is of sufficient quality for direct discharge to a receiving body.

Information will be presented on each step of the project development, including bench-scale testing, on-site pilot testing and the full-scale concept. Performance data will be presented on the rate of sediment removal, the attained solids from the material, the retention of heavy metal contaminants in the sludge, and the quality of the filtrate produced by the process. Information collected during this preliminary stage informed the conceptual design of a large-scale project to dredge, dewater and permanently store a significant volume of contaminated sediments from the site, while returning clean water back to the environment.

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Kevin Bossy

Kevin Bossy joined Bishop Water Technologies as CEO in October 2008 to lead the growth of this new company, which was spun out from Bishop Aquatic Technologies. Under Kevin's leadership, Bishop Water has expanded quickly to establish itself as a leading provider of simple, low-energy and cost-effective solutions for nutrient removal and solids management for municipal, industrial, agricultural and commercial applications.

Kevin has played a key role in the advancement of the Bishop Water solutions portfolio, leading projects to enhance the performance, value and sustainability of these environmentally focused products. The comprehensive range of solutions now includes highly effective, energy-efficient technologies for solids dewatering and containment; BioCord™ biological wastewater treatment; and chemical conditioning of wastewater and slurry materials. Kevin also works to build a robust network of distribution partners for these products, which now includes channels to market in Canada, United States, Australia /New Zealand, and Latin America.

These technologies have been used at hundreds of sites throughout Canada and have been recognized with numerous awards. Among these are the Ontario Exemplary Biosolids Management Award for the Bonnechere Valley Nutrient Management Facility; The Ontario Public Works Technical Innovation Award for the London Fly-ash Management System; and the Minister's Award for Environmental Excellence for the Perth WTP Residuals Management System.

Prior to joining Bishop Water, Kevin worked at RBC Capital Markets for 13 years. He then moved to the commercial and personal side of banking, as a Commercial Account Manager. In his role he offered financial advice and products to a variety of businesses – from small home based operations to companies with multi-million dollar sales.

Kevin was born in Malta and lived in England before making career moves within Canada, Singapore and Australia. In 2000 he and his family moved to the Ottawa Valley, where they enjoy a busy and active lifestyle. Kevin is a volunteer in the community, an avid skier and loves to golf.

Overcoming the Engineering Challenges with Giant Mine Remediation Project

Chris MacInnis, Crown Indigenous Relations and Northern Affairs Canada; Brad Thompson, Public Services and Procurement Canada; Rudy Schmidtke, AECOM and Darren Kennard, WSP

When the federal government formally assumed responsibility for Giant Mine in 2005, it inherited one of the most complex and challenging mine reclamation projects in Canada adjacent to Great Slave Lake and the City of Yellowknife. The technical challenges include needing to protect the environment from 237,000 tonnes of highly toxic arsenic trioxide stored in underground stopes and chambers by containing it through the development of a frozen shell, stabilising near surface underground voids by backfilling them with cemented paste tailings, relocating 770,000 m^3 of tailings, covering 1.7M m^2 of tailing, excavation and disposal of 3.7M m^3 of arsenic impacted material in covered pits and tailings areas, backfilling 7 open pits, realignment of Baker Creek which flow through the site, the quarrying of 4.6M m^3 of rock fill and 700,000 m^3 of fine grained soil material, and the construction and operation of a water treatment plant to treat arsenic-impacted mine water to the arsenic drinking water standard. Each of these elements presented their own unique engineering challenge and combined together added another layer of complexity related to the design and execution and integration of the work.

With the completion of the Environmental Assessment process in 2016, the Giant Mine Remediation Project tackled all of these challenges to inform the designs necessary to support the Water License approval and Government of Canada Treasury Board Project Implementation approval processes. These approvals were received in 2020 and 2022 respectively and with those in place the GMRP is ready to embark on the 15 year remediation process.

This presentation will provide an overview of the technical challenges which needed to be addressed as part of the GMRP and the innovative solutions that were designed to meet the remediation objectives.

Chris MacInnis

Mr. MacInnis is a civil and environmental engineer with a strong background in water quality and wastewater effluent treatment, contaminated site remediation, mine closure, and extensive project management. During the past 20 years he has specialized in contaminated site remediation and mine closure for federal government projects, including northern military and northern mine sites. He was recently appointed as a Canadian representative on the Standards Council of Canada's Managing Mining Legacies Working Group as well as the Mining Taskforce sub-group. Mr. MacInnis is currently the Director of the Giant Mine Remediation Project within Crown-Indigenous Relations and Northern Affairs Canada.

Roadside Vegetation Naturalization Pilot Project in Calgary, Alberta

Kent Cryer, Kashtin Gordon, Michael Quesnel and Elizabeth W. Murray, Earthmaster Environmental Strategies Inc.
Ethan Askey, Jenna Cross and Peter Yee, The City of Calgary
Mathis Natvik, University of Calgary
Gavin Wyman, ISL Engineering

The Calgary roadside naturalization pilot project was designed to evaluate changes in landscaping and vegetation management practices on select areas of public land to assess the potential to achieve environmental benefits through enhanced urban biodiversity and climate resilience, and reduce maintenance requirements, through the conversion of manicured turfgrass to native grasses and wildflowers. Traditional roadside landscaping practices have involved revegetating disturbed soil to reduce erosion, control flooding, and clean water runoff, often using turfgrass based on availability of seed, low cost, aesthetics, hardiness, and ease of installation/establishment. However, the resulting plant community has low biodiversity, requires mowing and weed control, and provides little support to the pollinator population. The use of native species of grass and wildflowers to replace turfgrass would reduce maintenance requirements, enhance the pollinator population, and provide plants that are adaptable and hardy to withstand extreme weather (including heat, drought, snow and ice). The installation of low maintenance landscaping with native vegetation would be more sustainable and resilient to climate change, facilitate the restoration of ecological function, reduce emissions, and reduce costs.

The project site is located in Northeast Calgary and consists of 5 hectares of turfgrass along a busy six lane divided arterial roadway (Trans Canada Highway) that functions as major city-wide transportation corridor. The existing turfgrass was mowed, de-thatched, and treated with herbicide to eradicate existing viable grass. Laboratory soil test results showed that some areas of the site had elevated salinity and the soil was low in nitrogen and phosphorous. The site was not fertilized and received no irrigation/watering. Mixtures of wildflower and grass seeds were selected based on the City of Calgary Seed Mixes guide as well as seed availability, and were installed using a no-till seed drill in mid-June 2021. To further support the pollinator population, 15 solitary and 15 social bee boxes were installed throughout the project area to increase available nesting habitat. Vegetation growth and health were assessed regularly during the growing season at a number of permanent assessment points. This presentation will highlight the project successes and learnings in the first two years of the three year project. Following seeding in Year 1, several species of annual wildflowers successfully germinated in the turfgrass stubble to facilitate the quick establishment of flowering species. The annual species provided a cover crop until the slower growing perennial species were established on the site and produced additional flowers. Year 2 saw the natural progression of the perennial flowering species replacing the annual species. Numerous native grass species were also successfully established on the site. The pros and cons of species selection will be discussed as well as considerations for installing native species near residential areas.

Kent Cryer

Kent Cryer, B.Sc., P.Ag., is a remediation manager with Earthmaster Environmental Strategies in Calgary, Alberta. He is originally from Estevan, Saskatchewan and is a graduate of the University of Saskatchewan with a degree in environmental science. Kent has over twenty years of environmental consulting, program development, and management experience in the commercial and upstream/downstream oil and gas industries. He has been a professional agrologist for 17 years and manages large remediation projects across Alberta. Kent has been the manager of the phytoremediation program at the company for over 15 years and has managed commercial field projects across Canada and the northern USA.

Addressing the Need for Data Governance Using Data Management Software as a Valuable Tool in Site Remediation

Bryan Shaw, CARO Analytical Services
Nick Tumney, ESdat Software by EScIS

With a steep rise in remote work over the last couple of years the need for centralized, cyber-secure, electronic field program management has never been greater. Often the most valuable commodity in complex site remediation is time and the ability to meet accelerated schedules set by clients or regulators. Lab data is a critical component of any remediation project, and the turnaround time of this data does not end when the final laboratory report is delivered. Data analysis must be completed before decisions can be made and this is where data management software plays a pivotal role in how quickly a project can move forward.

Environmental data management systems can offer full life cycle services from the initial lab quote to compiling historical data sets, all with the intention of saving time and money while maintaining a high degree of accuracy and data quality. With the analytical lab being an essential service to triage reliable data deliverables, input will be provided on how to best work with them in utilizing efficient processes in having visibility on quality data sets. The discussion would also include addressing data governance, and integrity with cyber-security measures to meet compliance and sustainability objectives. These valuable insights along with the adaptation of a well-integrated automated database provide environmental professionals the ability to streamline project management tasks, have confidence in quality measures, and effectively perform meaningful data investigation through reliable data sets.

Those currently working with a data management program will be interested to see some of the new features they can take advantage of to keep up with the latest innovations in field data and regulatory compliance monitoring. Industry-specific examples will be provided as an assessment of the beneficial impacts a well-organized data system has in meeting high-volume sampling events while implementing best business practices to effectively interpret automated data in offering environmental solutions. Environmental professionals, whether using internal systems, working with hand-built spreadsheets and manual manipulation, or any other data management tools, can use this presentation to guide how to implement environmental data management practices.

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Bryan Shaw

Bryan Shaw, Ph.D., is Senior Technical Support Scientist with CARO Analytical Services. Bryan holds a Ph.D. in Chemistry from the University of British Columbia as well as his Professional Chemist designation through the Association of the Chemical Profession of British Columbia (ACPBC). After gaining exposure in chemistry research through academia his career shifted to CARO Analytical Services in a client-facing role that utilizes his technical background. Bryan joined CARO as a Client Service Scientist handling some of CARO's key accounts in the environmental industry. As a Senior Technical Support Scientist Bryan takes advantage of the industry knowledge gained while managing accounts to provide clients with technical support and provide operational guidance according to the latest environmental regulations and analytical practices. This role also affords the opportunity to collaborate on special project needs and the development of new analytical methods

Nick Tumney

Nick, a Senior Implementation Specialist at EScIS Canada, oversees the implementation and client management of ESdat. This includes onboarding, developing & providing training services, and other support services. Prior to EScIS, Nick spent 10 years working as an environmental consultant in Melbourne, Australia. His roles included project management, environmental sampling & fieldwork, and data management tasks for various clients across the contaminated land sector. Nick has a B.Sc. specializing in Earth Science and a Masters of Spatial Information Science.

Excess Soil Management Technology at the Toronto Portlands, and Lessons Learned

Sajid Alimohamed and Morgan Chambers, QM Environmental

The construction of the Toronto Port Lands Flood Protection and Enabling Infrastructure Project (Toronto Port Lands Project) is taking place in parallel with the introduction of environmental regulations that enforce the tracking and reuse of soil. These regulations have led to the creation of new technologies to reuse the majority of the 1 million cubic meters of soil QM has excavated and managed.

New technologies like 3-D digital models, GPS driven machine control and remote sensing, cloud-based truck tracking, environmental and geotechnical analytical data management and a QP approvals platform work together to form a sophisticated, integrated tracking system.

As we all know, new technologies go a long way in simplifying work and optimizing outputs, however they come with their own set of challenges.

This presentation describes the new-age soil management technologies implemented by QM at the Toronto Port Lands project along with highlighting a few of the challenges and hiccups that have come along the way.

Sajid Alimohamed

Sajid Alimohamed, P.Eng., PMP is one of QM's Project Managers for Special Projects, working at the Toronto Port Lands for the past three years managing Soil Treatment, QP Approvals for Soil Reuse and earthworks construction of parks. After graduating from the University of Toronto's Chemical Engineering program he developed experience through environmental consulting and construction including in-situ and ex-situ soil treatment and reuse projects.

Morgan Chambers

Morgan Chambers, B.Sc. is one of QM's Project Coordinators for Special Projects, working at the Toronto Port Lands. She leads Project Controls and works with QM's cutting-edge intelligent soil tracking system on a daily basis to keep the project compliant. A University of Toronto graduate from the Earth Sciences department with a specialization on environmental policy, Morgan has been a key contributor to the Port Lands team for two years and counting.

How Modern Digital Platforms Can Help You Achieve 100% Budget Control

Vincent Lam, Matidor.com

Digital transformation is undoubtedly one of most researched topics amongst the 21st century. It is being defined as the using of digital technologies to improve business processes, culture and client experiences. For energy and environmental organizations, it means a new way to convert physical findings from the field, into digital, actionable insights, in order to maximize operational efficiency, team collaboration and cost savings. To many, it may seem like a matter of adding more apps and software into their already bloated technology stack - but is it really the case?

Ironically, organizations often suffer not because of the lack of apps, but of having too many uncoordinated "silo" systems and databases. Studies have shown that average companies deploy over 100 apps and software in different areas of operations, and still find themselves constantly catching up with competition. So the question remains - what are key considerations when bringing in your next piece of technology? What can it do to reduce your project management risks, especially in controlling your estimated and actual expenditures? During this presentation, Vincent Lam from Matidor.com will walk through the most common mistakes made by companies when adopting new software, and will provide some guidance to the latest technology landscape and deployment best practices.

Vincent Lam

Vincent Lam is the CEO and co-founder of Matidor.com. A visionary and 3x founder, Vincent built and sold his first Point-of-Sale system during his university years, and later joined Google to lead projects with the Google Earth team. Vincent has over 20 years of experience commercializing software innovations for environmental and energy companies, including GIS, marketplaces and AR/VR platforms. Vincent holds an MBA from the University of Ottawa and a BASc in Computer Engineering from UBC.

Knock-knock, Who's There? Using Next Generation Sequencing to Understand Your Environment

Melody Vachon, Jennifer Wilkinson and Phil Dennis, SiREM
Ron Gestler, Geosyntec and Courtney Toth, University of Toronto

Next generation sequencing (NGS), also known as second generation sequencing, is a high-throughput technology where the order of nucleotides is simultaneously determined in multiple DNA or RNA strands, allowing for rapid sequencing of full genomes or specific targeted regions. Targeted gene sequencing allows for quantitative analysis of mixed prokaryotic or eukaryotic populations in a variety of scenarios. In this presentation, we will highlight how we have used NGS to provide environmentally relevant information for enhanced in situ groundwater remediation, the characterization of microbial cultures used in bioaugmentation, characterization of plant associated bacterial endophytes in phytoremediation, and the characterization of water associated non-microbial fauna using eDNA approaches.

Characterization of microbial communities in groundwater for in situ groundwater remediation is routinely performed with NGS. Common uses include determining the potential for natural attenuation and assessing the need for, and impacts of, enhanced bioremediation. Examples of NGS data at chlorinated solvent and hydrocarbon contaminated sites will be provided to demonstrate how NGS enhanced our understanding of bioremediation processes and the subsurface conditions generally.

NGS approaches can also be used to characterize composition and stability of beneficial microbial cultures, such as the KB-1 and DGG Plus bioaugmentation cultures used in groundwater remediation. One specific use of NGS is to screen cultures against a database of known pathogens. This is something SiREM does early on in culture development, using NGS paired with a custom pathogen screening tool, to ensure bioaugmentation cultures are free of harmful pathogens before injection into the subsurface.

Endophytes are plant associated microbes that live in the tissues of plants and can impact phytoremediation performance. We implemented NGS approaches to analyze DNA from trees used in phytoremediation of chlorinated solvents and hydrocarbons. This approach facilitated identification of several endophytes implicated in the biodegradation of TCE, 1,4-dioxane, and hydrocarbons and helped us to better understand biodegradation processes occurring in phytoremediation systems.

NGS can be used to characterize aquatic flora and fauna through environmental "eDNA" analysis methods. These methods can be used to screen sites for the presence of fish, amphibians, aquatic insects, and even birds and mammals associated with aquatic systems. The eDNA methods are a cost-effective approach to screen for endangered or invasive species and to assess the overall health of ecosystems. We performed a preliminary study of aquatic fauna profiles at six locations in Ontario and in California including lakes, swamps, creeks, and estuarian locations. The studies indicated a wide range of biota that were consistent with the sampling locations.

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Recent years have seen rapid reductions in the cost and increased use of NGS in environmental applications. In this presentation we will present the use of NGS in multiple distinct scenarios, which represents the proverbial tip of the iceberg in terms of potential uses of these powerful technologies in environmental remediation and monitoring. Overall, there are numerous applications where high-throughput sequencing technology can allow you to gain a better understanding of the organisms living in or interacting with your site.

Melody Vachon

Melody Vachon is an Environmental Microbiologist at SiREM. Melody holds a Master of Science in Microbiology from the University of Waterloo, and Honours Bachelor of Science, Microbiology from the University of Guelph. At SiREM, Melody provides analysis for commercial NGS services, and implements new NGS and bioinformatics technologies. Melody also coordinates marketing activities and is a part of SiREM's innovation program contributing to multiple research and development projects.