FEDERAL CONTAMINATED SITES
SITES CONTAMINÉS FÉDÉRAUX

NATIONAL WORKSHOP 2010 ATELIER NATIONAL

Poster Presentations Abstracts

Adaptive Management in Practise – Deltaport Case Study

Geoff Wickstrom, Hemmera

The concept of adaptive management has been around for many years primarily focussed on large-scale resource management such as forestry and fisheries. More recently, it's begun to be implemented and refined for use in our venue of contaminated sites and land development scenarios. Several years back, the Vancouver Port Authority (now Port Metro Vancouver) received approval on its environmental assessment application to construct a third berth at its existing Deltaport container terminal located in Delta, BC. Given its location in an ecologically important area at the southern edge of the Fraser River estuary and remaining concerns around the potential affects associated with the terminal expansion, the port embarked on a process of developing an adaptive management strategy and subsequent implementation of the strategy. It's been a learning process for all stakeholders involved, but the information attained to date has been invaluable in terms of assuring regulators, the port, and the public that the environmental values of the area are being considered throughout the construction and post construction periods. The intent of the presentation will be to share the process through which the strategy was developed; the challenges and solutions identified through implementation; examples of results and how the program has been 'adapted' in response to those results, and exhibit the proactive response by the port to ensure their development initiative at Deltaport is successful not only from a financial perspective, but also from a social and environmental perspective.

Derivation of Toxicity Reference Values for 1,4-Dioxane

Ian Mitchell, Margaret Yole and Paul Wright
Meridian Environmental Inc.

1,4-Dioxane was commonly used as a stabilizer for chlorinated solvents, as well as being a component of products such as paints, varnishes, detergents, cements, stains, inks, shampoos and cosmetics and in chemical processing. As a result of its historical use, it occurs frequently at sites contaminated with chlorinated hydrocarbons; however, many site assessments did not include analyses for this chemical, and remediation methods employed for chlorinated hydrocarbons are often not effective for this substance. As a result, a large number of sites are believed to be contaminated with 1,4-dioxane, including many sites previously thought to have been successfully remediated.

In order to develop Canada-wide or site-specific remediation targets for 1,4-dioxane, it is necessary to have toxicity reference values (TRVs). There are currently no Health Canada TRVs for 1,4-dioxane, and the few evaluations conducted by other agencies do not reflect current data or Health Canada policies. Therefore, there is a need for current TRVs for 1,4-dioxane which reflect Health Canada policies for contaminated sites.

1,4-Dioxane is associated primarily with liver and kidney effects, although eye and respiratory tract irritation have also been observed. Cancer has been observed after chronic ingestion in animal studies, including hepatic and nasal tumours; the nasal tumours may be a result of direct inspiration of water into the nasal cavity by rats and may not be relevant for humans. While the mechanism of carcinogenicity is not known for certain, it appears that 1,4-dioxane does not react directly with DNA, but rather acts as a cancer promoter through an indirect mechanism, possibly by inducing cell proliferation, and physiologically-based pharmacokinetic models suggest a highly non-linear dose-response relationship. Therefore, despite its carcinogenicity, 1,4-dioxane was evaluated as a threshold substance. Due to growing awareness of the importance of short-term exposures for some risk assessments, oral and inhalation TRVs were derived for acute and sub-chronic exposures in addition to chronic exposures. The TRVs were derived

following Health Canada methods; benchmark dose modelling was used where possible. Data were inadequate to derive dermal TRVs.

The derived TRVs are believed to be protective of human health and suitable for use in human health risk assessment and guideline derivation. Key data gaps and uncertainties are also addressed.

DEW Line Clean Up 101: Historical Perspective

Don Beattie, Defence Construction Canada

This poster will touch on the background of the contamination vectors and development of the project. It will set context for the remaining posters as well as providing a glimpse at assessment and remediation in the unique arctic environment.

DEW Line Clean Up Project: Management and Lessons Learned

Constructed in the 1950s, during the Cold War era, the Distant Early Warning (DEW) Line formed a curtain of radar surveillance of North American airspace's northern (Arctic) approaches. Comprised of 63 DEW Line Stations located approximately 80 km apart along 5,000 km on the 66th to 70th parallel, in what is now Alaska, the Yukon Territory, the Northwest Territories, the Territory of Nunavut and Greenland. There were 42 sites located in Canada, of which the 21 smaller "intermediate" sites were decommissioned in the early 1960s and are now the responsibility of Indian and Northern Affairs Canada (INAC). The remaining 21 sites were closed between 1989 and 1993 and are now the responsibility of the Department of National Defence (DND) – it is these sites that the DND DEW Line Clean Up (DLCU) Project addresses.

The DLCU Project is one of the largest environmental clean up projects in North America with an implementation phase spanning two decades and a budget of almost $600M followed by a monitoring phase that is scheduled to last until 2037. The project is located within two land claim areas, the Inuvialuit Settlement Region and Nunavut Settlement Region. As of 2009, the project has completed all six sites within the Inuvialuit Settlement Region, and nine of the 15 sites in Nunavut, with the remaining six sites currently in the implementation phase. The project is built upon project-specific clean up protocols developed through innovative science with sound engineering solutions that range from on-site landfills through leachate containment to retrograde of contaminants for southern disposal. Successful project management of technical teams, logistics, contractors as well as regulatory and local stakeholders, relies on partnering principals and reflects the high level of the integration and communication management accomplished by the Project Management Office.

Five posters are offered for the workshop that will convey context, successes and lessons learned from managing this environmental project.

Quality Assurance and Project Lessons Learned

Douglas Craig, Defence Construction Canada

At the heart of all well managed projects is the plan-do-check-act cycle of quality assurance (QA). This poster will showcase the extensive integration of the DEW Line Clean Up (DLCU) QA program as well as provide a few lesson learned gems.

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Project and Data Management for a 35-Year Monitoring Program

Nahed Farah, Defence Construction Canada

Establishing a system to manage a program containing more than 189 site inspections, and extending over 35 years is a real challenge. This poster will display the strategic management plan, schedule, scope and risk mitigation techniques set up for the lifecycle of the project.

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Climate Change: Risk Review of Impact and Cost of Mitigation

Imad Jaradat, Defence Construction Canada

This will be a presentation of the case study in the risk identification, quantification and assessment that will show how DEW Line Clean Up (DLCU) Project is managing the uncertainty.

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Traditional Knowledge: Benefits and Methods

Steven Poaps, Defence Construction Canada

This poster will display the various methods that the DEW Line Clean Up (DLCU) Project undertook in the hunting and gathering of traditional, historical and archaeological knowledge. It will celebrate some beneficial results well as some of the more successful methods of soliciting traditional knowledge.

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Surfactant Enhanced Remediation of Contaminated Soil and Groundwater
(In-situ and Ex-situ Case Studies)

George A. Ivey, B.Sc., CEC, CES, CESA, Paul V. Wierbicki, P.E., P. Eng.
Ivey International Inc.

This poster will focus on the application of surfactant-enhanced remediation using non-ionic surfactants to improve the in-situ and ex-situ treatment of contaminated soil and groundwater.

Normally hydrophobic organic chemicals (HOC) exhibit limited solubility in water as the contaminants tend to partition and sorb (i.e., absorbs and or adsorbs) onto the soil or bedrock matrix. This partitioning can account for as much as >90% of the total contaminant mass. Consequently, the subject contaminants exhibit a limited 'availability' for in-situ and or ex-situ treatment. This includes technologies such as: pump and treatment, bioremediation, chemical oxidation, chemical reduction, soil washing and thermal desorption. Hence certain HOCs can persist in soils, bedrock, solid waste, wastewater and or groundwater for extended periods.

The sorption of contaminates onto solids is considered the principal limiting factor affecting the effectiveness of most treatment technologies. This coupled with complex chemistry, geology and hydrogeology only further complicates matters.

Surfactant enhanced remediation involves the use of surfactant formulations to selectively desorb and dissolve target contaminates from the solid to liquid phase. In addition, the surfactants lower the surface tension of water from 72 dynes to <30 dynes increasing the wetting and permeability properties of water in fine grain soil and bedrock fractures. The surfactants affect the sorption of HOC at the solid-liquid interface (i.e., the surface–H_2O–NAPL interface). As a result, the surfactants increase the contaminate solubility and improved 'availability' for rapid and cost effective treatment.

Surfactant Enhanced Bioremediation of F3 and F4 Contaminated Soils

George A. Ivey, B.Sc., CEC, CES, CESA, Ivey International Inc.
Dan Stangroom, Veolia Environmental Services

This poster will focus on the application of non-ionic surfactants to improve the "bio-availability" of higher molecular weight (HMW) compounds such as F3 (C16-C34) and F4 (C34-C50) heavy-end petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAH), among others, for microbial bioremediation.

During the past decade, much discussion has centered on the unavailability of absorbed compounds to soil microorganisms. It is generally now assumed that desorption and diffusion of bound contaminants to the aqueous phase is required for microbial degradation (W.P. Inskeep, J.M. Wraith, C.G. Johnston, Hazardous Substance Research Center, 2005).

It had been well established in literature that >90% of LNAPL and DNAPL contaminants prefer to sorbed (i.e., absorbed or adsorbed) on surfaces such as soil and bedrock, versus being in the dissolved water-phase. The sorption of contaminates to substrates is often considered the principal limiting factor affecting many remediation technologies (i.e., pump and treatment, oxidation, bioremediation, etc.). This fact limits the effectiveness of many bioremediation processes, as the targets contaminants are not "bio-available". Surfactants enhance bioremediation involves the use of surfactants to desorb the contamination and significantly improve the bio-availability of many

recalcitrant compounds. In doing so this allows for their improved microbial mineralization during the in-situ and ex-situ applications.

Examples of U.S. Remediation Projects Involving the Reuse of Treated Contaminated Soil and Sediment

Charles M. Wilk and Edward R. Bates
Remediation Technology Consultants, formerly from United States Environmental Protection Agency

Solidification/stabilization (S/S) technology is used to effectively treat contaminated soil and sediment in the remediation/site restoration of properties. One of the key advantages of S/S technology is that treated material can often be beneficially re-used on a project site contributing to the sustainable redevelopment of the property.

S/S treatment involves mixing a binding agent into the contaminated media (i.e., soil, sediment, sludge) or waste. The treatment protects human health and the environment by immobilizing hazardous constituents within the treated material. S/S has been successfully used to treat a large variety of hazardous constituents in many different forms of waste and contaminated media.

The technology has been applied to many federally-funded contaminated site remediation projects in the United States. Federal agencies that have used S/S on their sites include Department of Defense, Department of Energy, Environmental Protection Agency and Army Corps of Engineers.

The presentation will illustrate the technical principles of S/S treatment. The majority of the presentation will be describing several full-scale U.S. projects utilizing the technology. Projects described will include in-situ and ex-situ applications utilizing a variety of mixing devices, and treatment for inorganic and organic hazardous constituents. Examples may include: treatment and re-use of sediments from New York/New Jersey and New Bedford Harbors as engineered fill; treatment and re-use of dioxin-contaminated ditch sediment at the Naval Construction Battalion Center in Gulfport, Mississippi as pavement base; treatment of creosote and copper/chromium/arsenic-contaminated soil at the Brunswick Wood Preserving Superfund Site; and, in-situ treatment of coal tar-contaminated soil at several former manufactured gas plant sites.

Role of Solidification/Stabilization in the Sustainable Development of Brownfields in Canada

Yves Brousseau, Ciment Québec inc.
Colin Dickson, Cement Association of Canada

Brownfield redevelopment is an option that essentially encourages sustainable development rather that the development of new lands. However, the technology chosen to remedy site contamination can make a sustainability project more attractive. One of the technologies used to clean up brownfields is solidification-stabilization (S/S). This treatment method often makes it possible to reuse brownfield soil and sediment. The reuse of on-site materials improves the sustainability of a project by reducing the need to dispose of waste and consume new materials. The S/S treatment method consists of incorporating a binding agent that reacts to contaminated soil or sediment. The technology protects human health and the environment by capturing the hazardous compounds in the material treated. The Canadian site decontamination industry is using this effective treatment technology increasingly often; projects have been completed in every region of Canada.

S/S technology has been used to effectively treat hazardous organic and inorganic compounds. Treatment can be applied to soil or sediment on site (in-situ) or after their extraction (ex-situ). The technology can also be used to restore mining sites in operation or no longer in use that require clean up. The presentation offers examples of major brownfield treatment projects where S/S improved sustainability, including sites in Nova Scotia, Quebec, Ontario, Alberta and British Columbia. The clean-up of the Sydney Tar Ponds is the largest S/S project in progress in Canada.

Air Sparging and Soil Venting Remediation

Christian Gosselin, Golder Associates Ltd.

Golder has been mandated to assess the technical performance and feasibility of a large air sparging and soil venting remediation system installed to remediate soil and groundwater contaminated with volatile organic compounds (mainly benzene) that failed to reach the target remediation goals. The review revealed that although air sparging/venting was the proper technology for the site, the system was installed based on poor pilot test results. Many air sparging engineering fundamentals were also not taken into account, as well as a poor understanding of the subsurface conditions in relation to the operation of the remediation system. As part of the project Golder proposed to performed additional site characterization using membrane interface probes (MIP) and cone penetrometer test (CPT) and to realize a tracer air sparging/venting test using helium and sulfur hexafluoride (SF6) to map in three dimension the air distribution in the subsurface during air sparging. The data are used to redesign and modify the actual system to complete the remediation project. The poster presents the methodology, results and conclusions of this characterization study and tracer tests.

Surface-Modified Iron Nanoparticles for Remediation: Multiscale Investigations of Transport, Reactivity and Aggregation

Trishikhi Raychoudhury[1], Mihai Ciprian Cirtiu[1], Julien Fatisson[1], Jing Li[1], Mohan Bassnet[1], Line Lomheim[1], Audrey Moores[1], Nathalie Tufenkji[1], Subhasis Ghoshal[1], Kevin Wilkinson[2], Elizabeth Edwards[3], Eric Bergeron[4], Sylvain Hains[4], Christian Gosselin[4]

[1]McGill University

[2]Université de Montréal

[3]University of Toronto

[4]Golder Associates Ltd.

Results from a research project at McGill University in partnership of Golder Associates Ltd. on investigating transport, longevity and reactivity of surface modified nanoiron particles in chlorinated solvent-contaminated soils will be presented. Chlorinated solvents such as trichloroethylene, tetrachloroethylene and carbon tetrachloride are used in large volumes by various industries, but are extremely toxic and even trace quantities in the groundwater render the water unsafe for use. Uncontrolled or accidental discharges of chlorinated solvents into the subsurface at many industrial sites have led to extensive groundwater contamination. The Federal Contaminated Sites Inventory in Canada lists numerous sites contaminated by chlorinated solvents where urgent action is needed.

Nanoparticles of zero valent iron (reduced iron) can degrade chlorinated organic compounds very rapidly to innocuous products such as ethane and chloride ions. This makes the nano iron particles an excellent reactant for eliminating chlorinated solvents in the ground at contaminated sites. Iron is ubiquitous in soils and thus iron is considered to be a safe product to be introduced in to aquifers. Recent studies have however shown that iron nanoparticles, when injected into the ground through wells, are able to migrate only a few feet from the wells because they get filtered out by the soil. Laboratory studies indicate that modifying the surfaces of the iron nanoparticles with polymers improves their mobility in groundwater.

Pack sand column and sand tank experiments are being carried out to characterize transport of iron nanoparticles under typical aquifer conditions. Both synthetic and field groundwater samples obtained from chlorinated solvent-contaminated sites are being used in this study. In parallel, detailed studies are being conducted to characterize the aggregation and reactivity behavior of polymer-coated iron nanoparticles. The effect of these nanoparticles on microbial dechlorination activity is also being assessed. The research will help identify the conditions under which the surface modified nanoiron particles can achieve efficient and effective elimination of the chlorinated solvent compounds.

GoldSET © is your sustainability decision support tool

Sandra Beaulieu, Golder Associates Ltd.

GoldSET© (Golder Sustainability Evaluation Tool) is a sustainability decision support tool that evaluates the strengths and weaknesses of engineering projects with respect to environmental, social, economical as well as technical dimensions. It allows for an unbiased comparison of different options on the basis of sustainability principles. As such, it can help identify optimal solutions in a decision-making process based on the principles of sustainable development.

This sustainability analysis results in a "triple-bottom-line" assessment, expanding the traditional analytical framework from financial performance to environmental, social and economical performance. By providing a comprehensive and transparent framework to understand and manage the sustainability issues of a project, GoldSET© can achieve the following benefits:

- Improves the decision process involving complex issues by providing a framework for managing the risks associated with a project and a transparent decision process to support stakeholder engagement.
- Supports proactive stakeholder engagement – the evaluation process is rigorous and transparent. Stakeholders can better understand the alternatives and their respective impacts.
- Eases communication facilitating the issuing of a social licence to operate a project – the visual representation of performance with respect to sustainable development is a fundamental element which can be instrumental in improving the communication with communities. GoldeSET© is simple and easy to understand and every level, in the field as well as in the boardroom.
- Optimization of options – provides a framework to compare alternatives with a set of key criteria, trade-offs leading to optimized decisions are facilitated.
- Improves corporate image – a decision supported by a sustainability framework is an effective demonstration of a corporation's willingness to move forward with sustainable development, which can consequently promote a positive corporate image.

GoldSET© is a multi-criteria analytical tool meant to approach sustainability from the project level, to that a balanced assessment of the sustainability issues can to addressed, from the bottom-up within the organizations. GoldSET© is designed to bring sustainable development to the operational level so that organizations can "Walk the Talk."

The FRALMA Mobile Unit for the Destruction of Pesticides and PCB-Contaminated Oil On Site

René Cornellier and Norah Pierdant
Fralma Technologies Inc.

The most widespread and most effective technique for destroying PCB-contaminated oil is high temperature incineration or thermal destruction. Properly employed, it allows the PCBs/PCTs contained in these oils to be effectively destroyed without endangering the environment or human health. It is particularly effective for destroying oils contaminated with high concentrations. When improperly done, there is the possibility of highly toxic and harmful dioxin and furan emissions. However, a series of parameters exists to ensure that incineration is effective and that the constituents are destroyed. Temperature, gas flow and residence time are just some of the parameters that must be scrupulously followed and observed to ensure that a destruction rate of 99.9999% and over is attained. These parameters do not change, regardless of the size of the facility involved.

To date, the destruction of contaminated oil with high PCBs concentration has only been done by large-scale incineration plants. The FRALMA Unit presents an innovative way that can properly deal with destruction of high PCBs contaminated oil concentrations, in a small piece of equipment.

With the Stockholm Convention deadlines for store PCBs contaminated oil destruction just around the corner, this one ton/day capacity piece of equipment not only represents an economic way of destruction, but an advantage to the environment by eliminating transportation, handling and shipping of hazardous wastes.

The prototype used during tests in Canada was built in 2002 and updated during 2005-2009. The first commercial unit was shipped to Brazil in January 2010.

The commercial unit's main components are:

- Oil contaminated reservoir (UN approved) with pumping and homogenizing systems.
- Combustion chamber at 99.9% running at 850° C with diesel and using the contaminated oil itself when it gets to the right temperature as fuel to continue the batch.
- Destruction chamber running at 1,200° C and destroying all furans and dioxins, offers an efficiency of 99.9999% or better. Both chambers have sealed doors to facilitate cleaning inside the chambers when necessary.
- Exhaust and flue gas cooling tube that lowers the temperature of the gas from 1,200 to 500° C. The cooling tube presents a unique delta to this process.
- Dry scrubber system that utilises zeolite cartridges to capture chlorine.
- Detachable chimney with samples probes to continuously reads CO, HCL, CO2, O2, SO2 emissions.
- PC controls for gas analyzer and operation with a custom made program that offers the possibility of creating a variety of statistics, comparisons and profiles.
- Continuous gas analyzer system.
- Diesel generator for remote areas.

Development of an Aquatic Site Classification System (ASCS) for Federal Contaminated Sites in Canada

Murray Smith[1], Keith Lennon[1], Théophile Paré[2], Jean-René Michaud[2], Susan Winch[3]
[1]Fisheries and Oceans Canada
[2]Environment Canada
[3]Franz Environmental Inc.

The Federal Contaminated Sites Action Plan (FCSAP) provides funding to federal departments, agencies and consolidated Crown corporations to manage the human health and ecological risks associated with their contaminated sites and to reduce the associated federal financial liability. The National Classification System for Contaminated Sites (NCSCS), developed by the Canadian Council of Ministers of the Environment (CCME) is used by the FCSAP program for ranking remediation/risk management projects submitted for funding. The NCSCS, however, is not readily applicable to assessment of sites with a significant marine or freshwater component. Therefore, an Aquatic Site Classification System (ASCS) has been developed in order to complement the NCSCS and provide an evaluative framework for ranking marine and freshwater aquatic sites. The ASCS features a well-defined approach for applying numerical scores, particularly for qualitative considerations such as potential receptors and exposure pathways in order to minimize subjectivity while maximizing consistency in scoring. Though the Aquatic Site Classification System will be utilized across all federal departments and produce scores approximately equivalent to the NCSCS, the system is not intended to provide a general or quantitative risk assessment. Rather, it will be used solely as a tool for screening-level identification and prioritization of contaminated aquatic sites for the FCSAP program.

Reaching Through Cognitive Noise: Communicating Technical Health Risk Information to Stakeholders

Brenda Pichette, Health Canada

Objectives:
Determine an effective model to communicate technical health risk information to stakeholders which ensures their understanding of the information and still addresses the emotional side of issues.

Design:
The factors influencing public perceptions of risk, the risk environment in which we live, communication challenges of technical information, risk communication principles and the pitfalls of communication were analysed.

Outputs/Results:
Stakeholders perceptions of risk are influenced by many factors including the: effect on their well-being, effect on their communities well-being, ability to understand scientific information, and type of information their looking for.

Risk assessment terminology can be highly technical and meaningless to stakeholders if it's not communicated effectively.

Impacts/Outcomes/Conclusions:
Understanding how our stakeholders perceive risk as well as their capacity to understand technical information is an important first step in deciding how we present information to them. Risk assessments are highly technical and include information and language that is not always meaningful to all stakeholders. Identifying the appropriate language to use and the traps to avoid from the beginning help provide focus to our messages. Further realizing the underlying concerns of stakeholders will help in dealing with the emotional questions in an appropriate manner. The message model developed not only helps scientists prepare messages in advance, but also helps in responding to questions, comments and concerns.

New Plant Species for *In Situ* Phytoextraction of Polychlorinated Biphenyls (PCBS) from Contaminated Soils

Ficko, S.A.[1], Zeeb, B.A.[1], Rutter, A.[2]
[1]Royal Military College of Canada
[2]Queen's University

While CEPA level PCB-contaminated media (> 50 mg/kg) has largely been removed and destroyed in Canada, lower-level PCB-contaminated soil continues to be a problem in Canada and in many areas worldwide. Traditional remediation methods (e.g. excavation and incineration) are expensive due to high energy and transportation costs, and thus most cost efficient for highly contaminated media. There is a clear need for less expensive and more environmentally-friendly remediation techniques to deal with lower level contamination.

Phytoextraction is a relatively new method of remediating low-level PCB-contaminated soil, with *Curcurbita pepo* ssp *pepo* (pumpkin and zucchini) species being on the forefront of research in this area. However, as these species are crop plants, they require specific environmental conditions for optimal growth, must be re-planted every year, and may provide a pathway for contaminants to enter the food chain. Thus alternate plant species are currently under investigation.

Weeds were chosen for this research after their prolific growth was observed at two PCB-contaminated industrial sites in southern Ontario, Canada. Weeds are easy to cultivate and propagate, self-sustaining, inexpensive, and able to tolerate disturbed soils, making them ideal candidates for phytoremediation studies. To date, 27 different species of weeds have been shown to accumulate PCBs in both root (1.5-377.3 μg/g) and shoot (0.3 - 54.5 μg/g) tissues across the two sites. While most weed species have a smaller biomass than *C. pepo* plants, growing weeds at an optimum density per square metre will overcome this difference in biomass, and increase the total extraction by a variety of weed species to a quantity that is comparable to, or greater than that, of *C. pepo* plants.

To further investigate the differences in uptake between pumpkins and weeds, three species ox-eye daisy (*Chrysanthemum leucanthemum*), curly dock (*Rumex crispus*), and Canada goldenrod, (*Solidago canadensis*) were planted in monoculture plots, and harvested on a monthly basis over two field seasons at the two sites. While pumpkins have a relatively stable PCB level over time, PCB concentrations in weeds appear to decrease over time in a consistent pattern at both sites, showing that these species extract PCBs in a different way than pumpkins. Understanding these differences may lead to the development of more effective plants for remediation projects.

New Techniques to Efficiently Measure PCB Concentrations in Plants and to Immobilize Residual PCBS at Contaminated Sites

Langlois VS[1], Whitfield-Åslund ML[1], Rutter A[2] and Zeeb BA[1]
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While there is a long held view that plants are not capable of accumulating persistent organic pollutants (POPs) from soil, several studies have demonstrated that certain plant species (e.g., *Cucurbita pepo ssp pepo*) can successfully translocate these contaminants to their above-ground tissues. This characteristic renders these plant species good bioindicators for POP bioaccumulation in food chains and effective phytoextractors of soil contamination.

Therefore, there was a need to establish a rapid, cost effective and efficient method of determining accurate POP concentrations in plants. In the current study, individual *C. pepo ssp pepo* plants were grown in polychlorinated biphenyls (PCB)-contaminated soil and thoroughly subsampled to determine the pattern of PCB accumulation throughout the shoot. It was determined that the plant shoot PCB concentration could be accurately characterized by collecting a single representative stem sample at mid-plant (half way between the root and the end of the shoot).

Furthermore, we are also assessing a promising sequestration method to 'immobilize' any remaining PCBs after maximal phytoextraction has been conducted. This technology involves the use of granular activated carbon (GAC) as a soil conditioner. The objectives of this research are to determine the optimal concentrations of GAC required to completely inhibit bioavailability of PCBs in contaminated soils and to assess the impacts of GAC treatment on terrestrial invertebrate population health. A preliminary study demonstrated that high concentrations of GAC had the potential to inhibit POP bioavailability in *C. pepo ssp pepo*.

These methods will be useful for government regulators, conservation authorities and site owners, 1) to accurately and efficiently measure PCB uptake in plants, and 2) to apply GAC as a final step in phytoextraction of POP-contaminated soils.

Life Cycle Assessment of Remediation Options for a Remote Site Contaminated with Diesel

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Remediation of contaminated sites has obvious environmental benefits, but it can cause environmental impacts that are seldom considered during the design of remediation approaches. Impacts differ among technologies, and are likely to be greater at remote sites than in more populated areas due to transport over long distances. Environmental life cycle assessment (LCA) can quantify the overall environmental burdens of treatment systems, and help in selecting the most environmentally efficient approach. In the current study, the environmental performance of three treatment options was compared, using LCA, for the remediation of a diesel-contaminated site located on a Royal Canadian Mounted Police property in Hopedale, Labrador. The LCA focused on the secondary impacts of remediation (those associated with the remedial activities); the primary impacts (those associated with the changes in the site environmental quality) were handled through risk assessment. On-site ex-situ bioremediation in a temporary facility, followed by disposal in an unlined landfill, was found to have environmental impacts similar to in-situ treatment, but far less than those for off-site treatment. Transportation was the main contributor to overall pollution. Combining risk assessment with LCA may allow for more holistic management of contaminated sites combining the benefits of a site-specific assessment and avoiding shifting of the environmental burden.

Innovative Technology Use for Hydrocarbon Impacted Soil Remediation
Tuktoyaktuk, NWT

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Located near Tuktoyaktuk, Northwest Territories, the Department of National Defense (DND) site had hydrocarbon impacted soil that had migrated down to the permafrost. The site was a former tank farm in a remote part of Northern Canada. The remoteness of the site and unique geological and climate conditions of Northern Canada made remediation an interesting challenge. A biostimulation remediation strategy using biopiles was developed by Biogénie S.D.R.C., which included: minimization of soil handling, innovative use of wind to power the soil aeration system, adapted design of the biological treatment unit to the site characteristics, and maximum use of local resources. After three seasons of remediation, 100% of the soil was remediated to levels well below the Government of Northwest Territories industrial limits.

The site was removed from the Tuktoyaktuk community and cut off from any potential power sources by a bay. Diesel generators are typically used to power such soil aeration systems on remote sites. But this particular site, while challenging, also provided an opportunity for an alternative, innovative and unique environmental approach to

remediation of the site. The high wind velocities of the Tuktoyaktuk area, allowed Biogénie to use a wind-powered venting system to enhance the biostimulation process.

Biogénie's approach led to:

- The innovative use of a renewable energy source, significantly reducing fuel use and minimizing potential fuel spillage in transportation to the site;
- The remediation of contaminated soil on-site; and,
- Optimal use of local resources, both naturally occurring wind velocities and soil micobes, as well as, local Inuit subcontractors and workers.

Innovative Technology Use for Lead Impacted Soil Remediation
Swallowtail Lightstation, NB
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Located on Grand Manan Island, in Charlotte County, New Brunswick, the Swallowtail lightstation had metals impacted soil considered leachate toxic. The site is unique in that it is only accessible by helicopter, thereby limiting the options for remediation. Contamination of lead and barium was 8,730 mg/kg for barium and 67,400 mg/kg for lead. The present use of the site was related to waterway navigation while future uses possibly included tourism activities.

Halifax-based CleanEarth Technologies Inc. (CleanEarth) was brought in to develop a solution. A miniature version of CleanEarth's innovative and patented soil washing process, a method proven to be particularly effective for soil contaminated with metals, was developed for the project. The soil washing equipment was airlifted to the site. CleanEarth was able to remediate 95% of the soil to below targeted levels, whereas traditional remediation strategies would have involved airlifting contaminated soil to the mainland and trucking it to a landfill. CleanEarth's technology allowed for the soil to be remediated and left on site – maintaining the integrity the ecosystem and preserving the natural beauty of the island.

CleanEarth's approach led to:

- Actual on-site removal of contamination from the soil resulted in significantly smaller volume of material to be disposed of or recycled;
- On-site treatment of contaminants which resulted in fewer helicopter trips, thus lowering time and fuel costs, thereby also reducing the environmental footprint of the project; and,
- 95% of the contaminated soil was treated and left on-site.

Abandoned Foreign Vessels Disposal
Bay Roberts, NL
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Public Works and Government Services Canada

In 2002, two foreign owned trawlers were abandoned at the Department of Fisheries and Oceans (DFO) docks in Bay Roberts, Newfoundland. The vessels were left at the docks until DFO took ownership in 2006; at this point, DFO hired Public Works and Government Services Canada (PWGSC) to coordinate the disposal of the vessels.

The biggest issue with the vessels was the state of disrepair both were in and the presence of hazardous materials. While docked at the Roberts Bay dock, both vessels occasionally needed water to be pumped out. Hazardous materials related to the refrigeration systems were also a concern, and in 2007, 2,300 litres of liquid ammonia were removed from the vessels.

Various options for disposal were explored, but it came down to ocean disposal and salvage. Each option had its pros and cons, but salvage was eventually the option chosen. The Marine Recycling Corporation (MRC) was chosen to perform the salvage duties. Both ships were towed to Porte Colbourne, Ontario, where MRC's salvage yard is

located. MRC managed to recover approximately 1,000 tonnes of iron, 40 tonnes of aluminium, and 120 tonnes of non-iron metal from both trawlers. These materials were sent to audited and approved facilities for recycling. The salvage process generated approximately 175 tonnes of garbage and waste.

This was a unique project for PWGSC because of the story behind the abandonment of the vessels, as well as the complications associated with vessel disposal. The choice of the salvage option for disposal allowed for much of the ship to be recycled, as opposed to being sunk to the ocean floor.

Low-Level Radioactive Waste Management
Port Hope, ON

Anne Thompson and Justin Hick
Public Works and Government Services Canada

Port Hope, Ontario, was the home of an active uranium refinery that operated during the 1930s to 1970s. Ninety-percent (1.7 million cubic metres) of Canada's historic low-level radioactive waste can be found in the Port Hope area due to these activities. This waste has been managed through containment in various licensed and unlicensed facilities in the area. Under a tripartite memorandum of understanding (MOU) Natural Resources Canada (NRCan), Atomic Energy of Canada Limited (AECL) and Public Works and Government Services Canada (PWGSC) have recently formed the Port Hope Area Initiative Management Office to develop the final design and construction plans for the safe long-term management of the historic low-level radioactive waste in the Port Hope area. The MOU defines the roles and responsibilities of each agency as sponsor (NRCan), proponent (AECL) and major contracts manager (PWGSC).

In 2001, an agreement for the cleanup and the long-term safe management of low-level radioactive waste situation in the Port Hope area was signed by the Government of Canada and the local municipalities; this document defines the objectives and scope of the Port Hope Area Initiative (PHAI). The management solution was overseen by PWGSC and developed through five years of environmental and technical studies, as well as, extensive public consultation. The solution consists of two engineered aboveground mounds. The mounds isolate waste within thick multiple layers of a double baseliner and cover system. These facilities will isolate approximately 2.3 million cubic metres of waste from the environment. A long-term monitoring program will ensure the safety of the surrounding environment and community.

Radioactive waste is a unique remediation challenge. Considerations for the Port Hope project included: the size of the project (over 200 individual sites and 1.7 million cubic metres of waste), the impacts to the community as many of the sites are in a urban area, the financial impacts to the community, and the safe handling of low level radioactive waste. The relocation of the waste to central facilities designed to encapsulate radioactive waste will increase the quality of the Port Hope community and environment. PWGSC will continue to be significantly involved in the management of the project.

The Story of Brownfields and Smart Growth in Kingston, Ontario: From Contamination to Revitalization

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Kingston is one of Canada's oldest cities and the first Capital of Upper Canada. Strategically located at the confluence of the Rideau Canal system (a UNESCO World Heritage Site) with Lake Ontario, where they flow into the St. Lawrence River, it has had a centuries-long history as an important military centre, and hub for shipping, transportation, and related industries. The Kingston Brownfields program arose out of a strategic planning process in which the City identified the environment as one of its key priorities, a goal that was later articulated as making Kingston "*the most sustainable city in Canada*".

This book, The Story of Brownfields and Smart Growth in Kingston, Ontario: From Contamination to Revitalization, is the work of twenty-two authors from academia, industry and government, and explores the multi-disciplinary challenges of bringing brownfield properties back into productive use. It addresses these challenges by compiling individual chapters into three sections:

- Part One - The General Context: What are brownfields? Environmental, regulatory, legal aspects and remedial technologies for redeveloping brownfield sites.
- Part Two - Kingston's Experience: The political context, the role of consensus building and conflict management tools, social issues, public engagement, and Kingston case studies.
- Part Three - the Bigger Picture: Case studies elsewhere in Ontario and Canada, and lessons learned.