## Bioaugmentation in Ontario for Chlorinated Solvent Remediation, Case Studies and Lessons Learned

Remediation of chlorinated solvents in groundwater through bioaugmentation has become increasingly common in Ontario since the first application in 2009. Enhanced in situ bioremediation (EISB) for chlorinated solvents includes both the addition of electron donors (biostimulation) and the addition of beneficial dechlorinating microorganisms (bioaugmentation). Over the past 25 years EISB has been widely implemented in the USA, as a cost-effective and sustainable remedial approach that is now becoming more widely implemented at chlorinated solvent sites in Canada, and especially in Ontario, for reasons including:

The availability of locally produced bioaugmentation cultures and injection expertise;

Federal and provincial regulatory approvals for bioaugmentation cultures;

Locally available testing services for optimization and performance monitoring; and

Demonstrated success of bioaugmentation at a wide range of sites in Ontario.

Bioaugmentation cultures containing dechlorinaters including Dehalococcoides and Dehalobacter can be used to enhance bioremediation of chlorinated solvents such as PCE and TCE, DCE isomers, vinyl chloride, 1,2-DCA and 1,1,1,-TCA at sites where dechlorinating microorganisms are absent or poorly distributed. In addition, available remediation treatability studies and groundwater testing for quantification of dechlorinating microbes, and reductive dehalogenase functional genes, allows better selection of remediation amendments and assessment of bioaugmentation performance after implementation.

The KB-1® culture has been available for use in Canada since 2008 upon receiving regulatory approvals obtained through Environment Canada's New Substances Notification program (NSN). In 2024 a culture containing Dehalobacter (KB-1® Plus) that degrades inhibitory 1,1,1-TCA was also approved for us in Canada under the NSN program. In addition, the cultures, and numerous related injectable products, have been added to mobile Environmental Compliance Approvals (ECA) issued by the Ontario Ministry of the Environment Conservation and Parks. Since the first application 2009 more than 50 sites in Ontario have been bioaugmented with KB-1®.

Geologies where EISB is being implemented include fractured rock, as well as low permeability clay and glacial till. Low permeability strata are common in some of the most highly industrialized areas in Ontario. Case studies of EISB at chlorinated solvent sites in Guelph, Scarborough and Ottawa will be presented to highlight both challenges and opportunities for Ontario applications of EISB and lessons learned including performance in low permeability strata and in cold groundwater.


### Phil Dennis
### SiRem

Phil is a founding member and Senior Principal Scientist at SiREM. Phil Dennis has over 30 years of experience in research and management of molecular biology, microbiology, and environmental remediation laboratories and technology commercialization. Phil holds a Master of Applied Science in Civil Engineering from the University of Toronto and an Honours B.Sc. in Molecular Biology and Genetics from the University of Guelph. Phil currently focuses on managing innovation and research and development and directing molecular genetic testing services.

### Grant Walsom
### Trace Associates Inc.

Grant Walsom is a senior remediation engineer with over 30 years of experience and a Partner and Principal Engineer at Trace Associates. Grant Walsom, B.A.Sc., P.Eng., QP, is a Professional Engineer registered in Ontario and Alberta, and a registered Consulting Engineer in Ontario.

Grant's expertise has included Phase I and II Environmental Site Assessments (ESAs), Site Remediation, Records of Site Condition, and Environmental Compliance Audits. He has completed numerous Brownfield redevelopments and soil and groundwater remediation projects with virtually all contaminant sources, including metals, polychlorinated biphenyls (PCBs), petroleum hydrocarbons (PHCs), chlorinated solvents and volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) (including coal tar).

Grant currently is the Past-Chair of the Board of Directors for the Ontario Environment Industry Association (ONEIA) and a past co-Chair for the Excess Soils Working Group. He also serves on the Board of Directors for the Canadian Brownfield Network (CBN) as Past-President and now as an advisor. Grant proudly founded the Qualified Persons Community of Ontario (QPCO) and serves as the Council Chair and participates in many of the QPCO committees. He was proudly named the 2015 "Brownfielder of the Year" by the Canadian Urban Institute and received the ONEIA "Skip Willis Award" for 2019.