Using Subsurface Temperatures to Evaluate Vacuum Extraction System Performance

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Traditionally the pneumatic influence of a vacuum-based extraction system such as soil vapour extraction (SVE), multiphase extraction (MPE) or dual phase extraction (DPE) has been evaluated by measuring negative pressures (i.e., vacuum) induced on monitoring wells in proximity to extraction wells. This approach works well at sites where engineered surface seals such as asphalt pavement, concrete, or compacted clay exist, or where natural confining layers limit leakage and pressure losses through the upper earth to atmosphere. This case study explores the use of subsurface temperature measurements to evaluate pneumatic influence and remediation system performance for landscape settings that are prone to surface leakage.

In March 2017, a release of light crude oil from a pipeline break occurred in the Foothills region of western Alberta. The site is in a forested valley between a small mountain and a large hill where the surficial geology is comprised of approximately 10 m of poorly sorted sand and gravel drift with cobbles and boulders and occasional discontinuous clay layers. Underlying the drift is bedrock comprised of fractured shale and siltstone. Groundwater levels fluctuate significantly throughout the seasons and have varied as much as 8 m in the drift, heavily influenced by precipitation and spring snow melt. Groundwater levels tend to rise rapidly in late May or early June, sometimes as quickly as 2 m per week. Changes in groundwater temperature have also been observed confirming the groundwater regime is replenished in the spring by snow melt and surface water infiltration.

A combination of remedies has been implemented across various areas of the spill site including the use of SVE when the groundwater table is seasonally lower (generally Winter). Enhanced biodegradation has been a significant component of the reduction in PHC mass from the use of the SVE system, as it replenishes oxygen across the plume to support aerobic microbial processes. Matrix was interested in understanding if the use of SVE in the Winter was accelerating the reduction of subsurface soil temperatures which could further limit biodegradation activity. Several pressure-temperature transducers were suspended within the unsaturated zone of monitoring well standpipes in the areas SVE was applied.

The SVE system was intentionally operated in a pulsed mode whereby the system would run continuously for several days and then remain off for a few days to observe changes in oxygen and carbon dioxide levels as indicators of aerobic biodegradation activity. Unexpectedly, changes in temperature were directly correlated with the SVE system operating compared to when it was off, and between daytime and nighttime operation. Air being drawn into the subsurface from leaks in observation well caps and/or the surrounding soil was evidenced through temperature changes by the transducers. A more comprehensive study is being designed to confirm that the pneumatic radius of influence can be further assessed and quantified with observed changes in subsurface temperature, and how the subsurface temperature varies in the unsaturated zone with depth throughout the Winter and in relation to the saturated zone.

Branden Kellar

Branden has 10 years of environmental consulting experience with upstream oil and gas projects. Branden's experience in environmental consulting varies from contaminant hydrogeology assessment, site remediation, project execution, and technical data analysis. He received a Bachelor of Science in Environmental Science from Royal Roads University and holds a diploma in Chemical Technology from the Southern Alberta Institute of Technology. Currently, Branden works on groundwater and soil remediation systems including pump and treat, SVE, MPE, and vacuumenhanced pumping (VEP) systems from a project coordinator role, which includes system design, installation, operation, maintenance, monitoring, field support, data analysis, and reporting.

Gary Winthrop

Gary has a technical, management, and business development background of 26 years in environmental consulting services across Canada. He has a diploma in Civil Engineering Technology from the Northern Alberta Institute of Technology. Gary's environmental science and engineering capabilities with land, water, and air include all aspects of contaminated site assessment and remediation, complemented by experience with due diligence, permitting and approvals, and compliance monitoring. Gary's expertise includes contaminated site assessment, risk and liability evaluation, risk management, and remediation with substantive experience with vacuum based in situ systems. Gary has worked on hundreds of contaminated sites, mostly in Alberta but also many in British Columbia, Saskatchewan, Manitoba, Ontario, Northwest Territories, and Yukon.