

Legislative and Regulatory Requirements for In-Situ Chemical Oxidation and In-situ Bioremediation

In Ontario, any discharge of a contaminant to the natural environment other than water requires an approval under Section 9 of the *Environmental Protection Act* (EPA). This includes the injection of nutrients, chemicals and microorganisms, or re-injection of treated groundwater and/or surface water into the soil or groundwater. Therefore, the subsurface injection of any oxidizing agents used in ISCO requires a Section 9 EPA Certificate of Approval (C of A) from the Ontario Ministry of the Environment (MOE). A C of A application for ISCO requires that any potential discharges to air be described and monitored.

All wells (i.e., injection, recovery and monitoring) must be installed, operated and abandoned in accordance with the Wells Regulation (Ontario Regulation 903 made under the *Ontario Water Resources Act* (OWRA), as amended). If the remedial system involves the extraction of 50,000 litres or more of water per day, an OWRA Section 34 *Permit to Take Water* is required.

If contamination extends off-site, or if the remedial process causes contamination to migrate off-site, other sections of the EPA may apply, such as Sections 14, 15, 17, 18, and 157.

In addition to the above-listed regulatory requirements, implementation of ISCO (as well as any remedial action) must comply with the provisions under the proposed *Drinking Water Source Protection Act* (MOE 2004). According to this Act, Source Protection Boards and Source Protection Committees (to be formed) will have the task of preparing a source water protection plan for each watershed area and/or region in Ontario designated as a source of drinking water. These plans will (among other parameters) specify the quality of source water to be protected. Imposition of quality criteria could result for sites where groundwater remediation occurs. This has particular implications for ISCO in terms of controlling and monitoring the release of metals and unwanted treatment by-products, which are regulated drinking water contaminants or those which could impair drinking water quality. The *Drinking Water Source Protection Act* does not preclude use of ISCO, but imposes additional regulatory requirements for technology implementation. With respect to the Act, ISCO may be applied to remediate contaminated sites which exist in source water protection areas.

The Ontario Ministry of the Environment does not have clearly formulated requirements regarding the use of ISCO on contaminated sites. Specifications on data needs and documentation required for the evaluation of remedial action employing ISCO or approval of trials and technology implementation are not defined either. To implement ISCO, it is recommended that a proponent:

- Create a three-dimensional (3-D) conceptual model of subsurface conditions based on sufficiently detailed site characterization;
- Perform a bench-scale and/or pilot scale test to evaluate the site-specific effectiveness of the technology;
- Develop a remedial action plan (including a design and operation plan with contingencies); and
- Develop process monitoring and confirmatory monitoring plans.

The procedure listed above is generally compatible with the requirements imposed under Section 9 of the EPA and as such would facilitate the review/approval stage of a remedial solution and subsequently lead to proper implementation of ISCO.

Post-treatment (Confirmatory) and Closure Monitoring

Confirmatory groundwater monitoring is required to demonstrate that contaminant concentrations are declining, (i.e., that contaminant migration in groundwater is controlled and hazardous vapours are not emitted). The minimum recommended requirements are to monitor groundwater quality at one upgradient location, at one location within the contamination source, a minimum of two locations within the contaminant plume, and a minimum of two locations along the downgradient property boundary (if necessary).

Proponents should be aware that it is possible that contaminant concentrations in groundwater rise during and/or after the application of ISCO (particularly, permanganate oxidation). It is therefore necessary to carry out and continue on with the confirmatory groundwater monitoring until concentrations in these media have stabilized or are confirmed to be on a downward trend. Monitoring wells should be sampled periodically (e.g., every 3 months) for a year after the termination of treatment to observe contaminant concentration trends (ITRC 2005). If an increase in contaminant(s) concentration is detected over two consecutive quarters, it is likely that rebound occurred and that additional oxidant injections might be necessary. In the US, the requirements for the extent of monitoring that would be sufficient for site closure varies between States. Generally, regulators request long-term monitoring (e.g., annual

monitoring for three years), which will confirm that a post-oxidation equilibrium is established and that contaminant concentrations will remain below the specified criteria (ITRC 2005). In Ontario, the requirements for closure monitoring following ISCO are not specified.

In Situ Chemical Oxidation Safety Advisory

(adopted from the Florida Department of Environmental Protection, March 28, 2002. Assessment of remedial technology using hydrogen peroxide as an oxidizer for groundwater and soil remediation - letter to American Remediation.

The volatility of some contaminants may be sensitive to temperature and there could be a significant change in both the concentration and distribution of flammable vapours and/or toxic non-flammable vapours when using an in situ chemical oxidation method. This dynamic environment is less predictable than most other clean up situations, where less powerful remediation methods are unable to drive the cleanup by greatly changing a site's established equilibrium of contaminants that are distributed amongst the vapour, liquid, and adsorbed phases. Therefore, both precautionary and preventative measures are appropriate.

As is the case in any petroleum or flammable solvent remediation effort, design considerations must take potential fire and explosion hazards into consideration, so that appropriate equipment and operating procedures can be specified for their prevention.

The suggested items to consider are, but not necessarily limited to:

- a. The potential for subsurface migration of vapours, either through pathways in the aquifer and soil itself, or via underground conduits such as sewer lines, utilities, storm drains, etc., and the destination of those pathways should migration occur;
- b. The presence of free product in the subsurface, either in underground utilities, or in the form of non-aqueous phase liquids, which could be volatilized by the heat of an exothermic chemical reaction, in concentrations which exceed the lower explosive level;
- c. The presence of underground petroleum or flammable liquid storage tanks and dispenser pipelines which may be near the source of heat generated by chemical oxidation reactions, and measures to prevent them from exposure to excessive amounts of heat;
- d. Identification and control of possible ignition sources (electrical equipment, devices, and switches, vehicle exhaust sparks, mechanical sources of sparks, etc.) at potential vapour migration pathway destinations;
- e. Monitoring of vapour concentrations, for comparison with lower explosive levels, at the site and/or in conduits and other potential pathways during proper operation of the chemical oxidation system;
- f. The chemical reactants involved and the amount of heat liberated by their reaction;
- g. Monitoring of aquifer and/or vadose temperature during treatment;
- h. A maximum temperature that may be tolerated before shutting down the operation is necessary;
- i. Control of reactant concentrations and/ or quantities as a means of controlling temperature;
- j. The possibility of using a vacuum extraction system to collect vapours at sites where significant amounts of volatilization is expected to occur; and
- k. Safety of workers involved with the actual handling of chemicals.
- l. The forgoing list should not be applied in blanketed fashion, and technical judgments should be made on a site-specific basis. For chlorinated hydrocarbon remediation via chemical oxidation methods, the risk of a fire is reduced, since

those compounds are not flammable. However, caution should be exercised in order to prevent the release or migration of quantities and concentrations of chlorinated vapours that may be harmful from a toxicological or environmental standpoint.