Florida Department of Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Rick Scott
Governor

Carlos Lopez-Cantera
Lt. Governor

Jonathan P. Steverson
Secretary

March 21, 2016

Via Electronic Mail
Carol Winell (carol@georemco.com)

Carol Winell
G.E.O. Incorporated
1612 Jenks Drive
Corona, California 92880

Re: **Gas Thermal Remediation (GTR™) and C3 Technology Vapor Condensation**

Dear Ms. Winell:

The Division of Waste Management (DWM) hereby accepts Gas Thermal Remediation (GTR™) and the Cooling Compression Condensation (C3) vapor treatment system for in-situ and ex-situ remediation of petroleum, chlorinated hydrocarbons, and other suitable contaminants in groundwater and soil. There are no objections to the use of GTR™ and C3 for the remediation of contaminated sites in Florida, provided a site-specific Remedial Action Plan is approved by the Department. Regulatory information is provided in Enclosure 1, and supplemental information in Enclosure 2.

GTR™ heats soil and groundwater via thermal conductivity, using an array of vertical or horizontal, steel heater wells near soil vapor extraction (SVE) wells and/or multi-phase extraction (MPE) wells. At the surface, attached to each heater wellhead pipe, is its own light weight, natural gas, propane, or diesel-fired burner that produces hot combustion air, which is circulated through the heater well's subsurface steel tubing. The combustion air does not come into direct contact with the soil and groundwater, but is instead routed back to the surface by the tubing, where it is vented to the atmosphere. The heater wells operate between 400°C and 700°C in order to produce targeted subsurface treatment temperatures ranging from 70°C to 400°C, depending on the site and its contaminants.

Subsurface contaminants that are volatilized or made more mobile by the heat are collected by nearby SVE and/or MPE wells and brought to the surface, where they are captured by the C3 equipment train that uses (1) a vapor-liquid separator; (2) a 150 pound per square inch vapor compressor; (3) air-to-air heat exchangers that condense and remove moisture; (4) refrigeration to approximately -40°C that condenses volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs); and (5) regenerative adsorption beds to remove any remaining VOCs.

The DWM does not provide endorsement of specific or brand name remediation products and processes, but it does recognize the need to determine their acceptability in the context of environmental regulations, protection of public health, and safety. In no way shall this regulatory acceptance be construed as certification of product performance. Upon acceptance, vendors must market their products and processes on their own merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace.

Remedial Action Plans that propose the use of an accepted product or process should include a copy of the acceptance letter in the plan's appendix, and reference it in the text of the document. It is not a requirement that a particular remediation product or process have an official acceptance letter in order for it to be proposed in a site-specific Remedial Action Plan, but the plan must contain sufficient information about the product or process to show that it meets all applicable rules and regulations.

The DWM reserves the right to revoke its acceptance of a product or process if it has been falsely or incompletely represented. Additionally, DWM acceptance of any product or process does not imply it has been deemed applicable for all cleanup situations, or that it is preferred over other treatment or cleanup techniques in any particular case. A site-specific evaluation of applicability and cost-effectiveness must be considered for any product or process, whether conventional or innovative, and adequate design details must be provided in a site-specific Remedial Action Plan submitted for review and approval. If you have any questions, please contact Rick Ruscito at (850) 877-1133, extension 3722 or by e-mail at RRuscito@ene.com.

Sincerely,

Rick Ruscito

Rick Ruscito, P.E.
Ecology & Environment, Inc.
Petroleum Restoration Program Section 6
RRuscito@ene.com

Susan K. Fields

Susan K. Fields
Environmental Administrator
Petroleum Restoration Program
Susan.Fields@dep.state.fl.us

enc: (1) Regulatory Information
(2) Supplemental Information

c: John Wright - FDEP/Tallahassee

ENCLOSURE 1

REGULATORY INFORMATION

1. Regulations: Chapters of the Florida Administrative Code (F.A.C.) that may be applicable, either in part or in their entirety, include but are not necessarily limited to Chapter 62-520, Ground Water Classes, Standards, and Exemptions; Chapter 62-528, Underground Injection Control (UIC), particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapter 62-550, Drinking Water Standards; Chapter 62-777, Contaminant Cleanup Target Levels; Chapter 62-780, Contaminated Site Cleanup Criteria; Chapter 62-782, Dry Cleaning Solvent Cleanup Criteria; and 62-785, Brownfields Cleanup Criteria.

2. Hazardous Air Pollutant (HAP) emissions: For the contaminants of concern being remediated at a cleanup site, rules 62-780.700(4)(a) and (e), F.A.C., require air emissions treatment for at least the first 30 days of operation for on-site treatment systems. Treatment may be discontinued after the first 30 days of operation if the total air emissions from all on-site remediation equipment systems do not exceed 5.5 pounds per day for any single HAP or 13.7 pounds per day for total HAPs. If necessary, as indicated by GEO, granulated activated carbon can be used to polish vapor from the C3 vapor treatment system to meet state or local requirements.

3. Aqueous phase liquid (APL) effluent: Aqueous phase effluent from the vapor/liquid separator and the compression/heat exchanger module of the C3 vapor condensation system that meets the groundwater cleanup target levels set forth in Chapter 62-777, F.A.C., may be disposed on site via infiltration. It may also be disposed by way of underground injection, storm water sewer or sanitary sewer. For more information about disposal of effluent by way of injection, and a requirement to provide notice to the Underground Injection Control Section, see the guidance document titled "BPSS-8 Effluent Disposal via Injection Well", currently located at web page www.dep.state.fl.us/waste/categories/pcp/pages/active.htm. For information about disposal via National Pollutant Discharge Elimination System (NPDES) to a storm sewer, see the guidance document titled "BPSS-3 Design Requirements and Procedures for NPDES Discharges", also currently located at web page www.dep.state.fl.us/waste/categories/pcp/pages/active.htm. For disposal via sanitary sewer, observe the requirements of the local sewer use ordinance.

4. Non-aqueous phase liquid (NAPL) effluent: The NAPL produced by the C3 vapor treatment system, as indicated by GEO, will be temporarily containerized in appropriate vessels for recycling or proper disposal. Depending on the type of contaminants being remediated, the NAPL will either be light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquid (DNAPL).

5. Pilot study: Per rule 62-780.700(2), F.A.C., a pilot study may be conducted prior to the design of a full-scale treatment system.

ENCLOSURE 2

SUPPLEMENTAL INFORMATION

The DWM below passes along some of the information provided by Good Earthkeeping Organization (G.E.O. Incorporated) and provides a list of safety topics to consider in the design and operation of a GTR™ system. Neither the G.E.O. information passed along here, nor the list of safety topics added by the DWM shall be considered exhaustive. Contact G.E.O. or visit their webpage for more information.

1. Heater wells and vapor extraction wells: Steel is the material of construction for GTR™ heater wells because it is a good conductor of heat, and is capable of withstanding the high temperatures of the combustion gases that pass through them. Steel is also the material of construction for the vapor extraction wells used to recover contaminants, for the same reason.

2. Burner safety features: The burners that produce the hot combustion gases for thermal remediation are located atop the heater wells. The safety features built into the burners are associated with their fuel distribution system (usually natural gas or propane); industrial burner controls; and emission controls; for example: control of the air/fuel ratio; purge air; lower explosive level; ignition controls; flame detection; etc.

3. Media: GTR™ can be used for the treatment of soil and groundwater, in-situ or ex-situ.

4. Thermal treatment radius of influence: 1.0 – 1.5 meters (3 – 5 feet) from each heater well. G.E.O. indicates that heat does not spread any further from the treatment area than that distance.

5. Spacing of heater wells: 3 to 10 feet apart.

6. Subsurface temperature: A typical average final subsurface temperature for the remediation of gasoil type distillates is 200 °C with local temperatures around the heater tubes reaching 400 °C. The final treatment temperature depends on the kinetics of contaminant desorption.

7. Monitoring of subsurface temperature and vacuum: Monitoring wells for the measurement of temperature and pressure are installed at the centroids (center points) between the heater wells. Each monitoring well contains a pressure transducer to monitor the vacuum level of the vapor extraction system, and a bundle of thermocouple wires of different lengths to measure the temperature at discrete depths in the vadose. Temperature information can be used to model temperature gradients, and to prepare isotherm diagrams of the average temperature in the subsurface, like those shown in G.E.O.'s literature for the gradients observed during a pilot study at 10, 60, and 90 days.

8. Ensuring thermal coverage: The locations of temperature monitoring wells at the centroids of the triangular interstices (formed by the staggered layout pattern of the heater wells) are the coldest points in the heating grid, because they are furthest from the heater wells. Achievement of target treatment temperature at a centroid offers assurance that the entire triangular-shaped interstice has been heated, not just a small immediate area around each heater well.

9. Cooling: At the end of treatment, if necessary, water can be used to cool the soil.

10. Insulation: G.E.O. indicates that it can provide thermal protection (insulation) of infrastructural elements, but their position needs to be indicated by the client.

11. Limitations: GTR™ is suitable for all types of soil, except peat soil because of the high risk of settlement.

12. The fiberglass underground storage tank (UST) and polyvinyl chloride (PVC) piping information below is provided by the Division of Waste Management.

    a. Fiberglass-reinforced plastic USTs that might already be present at a site prior to thermal remediation are typically specified for the storage of petroleum fuels at 150 degrees Fahrenheit (65.5 degrees Centigrade) or less.

    b. PVC pipe used to construct monitoring wells that might already be present at a site prior to thermal remediation is typically specified for the conveyance of fluid at 140 degrees Fahrenheit (60 degrees Centigrade) or less.

13. Safety topics to be taken into consideration during the preparation of site-specific Remedial Action Plans proposing GTR™ should include, but should not be limited to the list below that is provided by the Division of Waste Management.

    a. Determine whether the USTs and their associated piping should be removed from the site prior to thermal remediation, or emptied and filled with an inert gas. If a situation is such that a tank is not within the zone to be thermally treated, and is not so close to the zone as to warrant the emptying of its contents, then consideration could be given to the blanketing of the partially filled tank with inert gas. Consideration should also be given to a means of verifying that the inert gas blanket remains in place during, and after the period of active treatment until it is no longer needed.

    b. Determine the minimum tolerable distance between heater wells and any existing fiberglass and/or steel USTs and their associated piping.

    c. Determine whether the temperature of the subsurface around a UST system should be monitored, and whether the temperature of the liquid inside the tank and the vapor space above the liquid should be monitored.

    d. Determine the minimum tolerable distance between heater wells and any existing PVC monitoring wells if the PVC wells will not be removed or replaced by stainless steel prior to thermal remediation.

    e. Provide safe aboveground venting of the hot combustion gases after they have completed their path of travel through the subsurface in the heater wells.

    f. Identify subsurface utilities and their materials of construction; their resistance to heat; and whether non-heat-resistant utilities should be relocated or replaced with stainless steel.

g. Provide adequate surface seal for the vapor extraction system to prevent fugitive emissions.

h. Identify drains, sewers, other utilities, and other subsurface features that could serve as potential conduits and pathways for unwanted vapor migration, and monitor their outlets and termination points. For flammable contaminants, identify and remove potential ignition sources along the potential migration pathways, and monitor the concentrations of the contaminant vapors for comparison to their lower explosive levels. For nonflammable contaminants such as chlorinated solvents, identify potential receptors along the migration pathways, and monitor the concentrations of the contaminant vapors for comparison to the maximum allowable limits recommended by toxicologists.

i. Determine the potential for vapor intrusion into buildings, and address or monitor accordingly.

j. Observe the National Electrical Code for Class I, Group D, Division 1 and 2 hazardous area requirements for electrical equipment located in hazardous areas.

k. Provide proper personal protection for workers.

l. Give consideration to the safety of neighbors and passersby, and provide a security fence with a locked gate to prevent the entry of unauthorized persons to the work area.

14. Sampling during active thermal remediation: If samples of hot soil and groundwater will be taken during the active phase of the thermal remediation, then a means by which to safely obtain the samples without burning the sample taker shall be used, and the sampling method must be such that none of the volatile contaminants are driven off by the heat before the sample is sealed in a container and shipped for laboratory analysis.

15. Confirmation sampling: Upon completion of active remediation, representative samples of the soil must be taken for laboratory analysis to confirm that the contaminants of concern have been remediated to their required soil cleanup target levels. Additionally, for the groundwater, a minimum 1-year period of post active remediation monitoring (usually on a quarterly basis) is required, during which the contaminants of concern must meet their groundwater cleanup target levels for at least the final 2 of the 4 quarters to qualify for site rehabilitation completion.