



**FLORIDA DEPARTMENT OF
ENVIRONMENTAL PROTECTION**

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September 16, 2013

Via Electronic Mail

DBaird@Regenesis.com (Drew Baird, P.G.)

Craig Sandefur, V.P. of Technology
Regenesis
1011 Calle Sombra
San Clemente, California 92673

Re: **PersulfOx™**

Dear Mr. Sandefur:

The Florida Department of Environmental Protection's Division of Waste Management (Division) hereby accepts Regenesis' PersulfOx™ (sodium persulfate oxidizer and sodium silicate catalyst) for the destruction of petroleum hydrocarbons and other suitable contaminants in groundwater and soil, in situ and ex situ, via chemical oxidation. Regulatory information is provided in Enclosure 1, and supplemental information in Enclosure 2.

There are no objections to the use of PersulfOx™ provided: (a) the considerations of this letter are taken into account; (b) a site-specific Remedial Action Plan is submitted for review and approval by the Department; and (c) the Remedial Action Plan specifies the size and duration of a temporary injection zone of discharge for sodium, sulfate, pH, total dissolved solids, iron, and manganese, and proposes adequate groundwater monitoring of them pursuant to Rule 62-520.310(8)(c), F.A.C. [formerly 62-522.300(2)(c), F.A.C.].

While the Department of Environmental Protection does not provide endorsement of specific or brand name remediation products or processes, it does recognize the need to determine their acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health and safety. Vendors, upon receipt of an acceptance, must market a product or processes on its own merits regarding performance, cost and safety in comparison to competing alternatives in the marketplace. This acceptance letter shall not be construed as either an approval of the product or a certification of its performance.

It is not a requirement that a remediation product or process obtain an acceptance from the Department in order to be proposed for use in a site-specific Remedial Action Plan, but the plan must contain sufficient information to show that the product or process meets all applicable and appropriate rules and regulations. For PersulfOx™, a copy of this acceptance letter should be included in the appendix of each site-specific Remedial Action Plan that proposes its use.

The Department reserves the right to revoke its acceptance of a product or process if it has been falsely represented. Additionally, Department 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 site-specific design details must be provided in a Remedial Action Plan. If you have any questions, contact Rick Ruscito at (850) 877-1133, extension 3722, through Mail Station 4590 at the letterhead address or by E-mail at RRuscito@ene.com.

Sincerely,



Rick Ruscito, P.E.
Ecology & Environment, Inc.
Petroleum Restoration Program - Section 6



Rebecca Lockenbach
FDEP Section 6 Leader
Petroleum Restoration Program
Rebecca.Lockenbach@dep.state.fl.us

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

History

PPL 472 - INN 204 -
Burlab 1428 - ITR 69673
9/16/2013

REGULATORY INFORMATION

- a. Groundwater cleanup standards: The onus shall be on users of PersulfOx™ to ensure that all applicable groundwater contaminant standards will be met at the time of project completion, for petroleum and other contaminants that may be present, any residuals associated with the ingredients of PersulfOx™ and any by-products produced as a result of chemical or biochemical reactions involving those ingredients. The following chapters of the Florida Administrative Code (F.A.C.) are cited: Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C. for groundwater classes and standards, and groundwater permitting and monitoring requirements; Chapter 62-528, F.A.C., for Underground Injection Control (UIC), particularly Part V, for Class V, Group 4 aquifer remediation projects; 62-780, 62-782, and 62-785 F.A.C., for cleanup criteria; and Chapter 62-777, F.A.C., for cleanup target levels.
- b. Injection well permit: The issuance of a site-specific Remedial Action Plan Approval Order by the Department for injection of PersulfOx™ into an aquifer constitutes the granting of a Class V injection well permit. [62-528.630(2)(c) and 62-528.640(1)(c), F.A.C.]
- c. How to obtain permission for a temporary injection zone of discharge: For injection-type, in situ aquifer remediation, the composition of an injected fluid must meet the drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum general groundwater criteria of Chapter 62-520, F.A.C., pursuant to Underground Injection Control Rule 62-528.600(2)(d), F.A.C. Chapter 62-777, F.A.C., provides additional groundwater criteria for specific chemicals of regulatory interest. Aquifer remediation fluids that do not meet these requirements must seek permission for a temporary injection zone of discharge. In the case of PersulfOx™, at injection fluid concentrations of less than or equal to 20%, the following parameters must seek permission for a temporary injection zone of discharge pursuant to Rule 62-520.310(8)(c), F.A.C.: sodium, sulfate, total dissolved solids, pH, iron, and manganese. (Iron and manganese are not ingredients of PersulfOx™ but rather trace metals that may be present in sufficient concentration, per assay by the supplier of the sodium persulfate, to require zone of discharge permission.) Regenesis does not anticipate that the concentration of PersulfOx™ in the fluid to be injected will be greater than 20%, nor does this acceptance by the Division of Waste Management extend to concentrations greater than 20%, the threshold at which chromium must be included as a zone of discharge parameter, for which permission by way of variance rather than rule is required.

In order to obtain permission for a temporary injection zone of discharge by way of Rule 62-520.310(8)(c), F.A.C., a site-specific Remedial Action Plan proposing the use of PersulfOx™ must: (a) indicate the overall concentration of PersulfOx™ in the fluid to be injected; (b) specify the size of the injection zone of discharge in which the temporary exceedance could occur; (c) specify the period of time that the temporary injection zone of discharge will be needed; and (d) propose groundwater monitoring of sodium, sulfate, total dissolved solids, pH, iron, and manganese. In most cases quarterly sampling of some representative monitoring wells in the treatment area and its downgradient edge should suffice. Department approval of a site-specific Remedial Action Plan that meets the requirements of Rule 62-520.310(8)(c), F.A.C., constitutes the granting of permission for a temporary injection zone of discharge for aquifer remediation purposes.

The current groundwater standards for the PersulfOx™ parameters that require a temporary zone of discharge are sodium (160 milligrams per liter, mg/L), sulfate (250 mg/L), total dissolved solids (500 mg/L); pH (range 6.5 – 8.5); iron (0.3 mg/L); and manganese (0.05 mg/L). If the groundwater's natural-occurring background level of any of these parameters at a specific remediation site does not meet the established groundwater standard, then the residual level of that parameter by the time the temporary zone of discharge period ends shall be no worse than the pre-existing, pre-injection background level.

- d. Utilization of wells: If a remediation site happens to have an abundance of monitoring wells, then the Division of Waste Management has no objection to the use of some wells for the application of PersulfOx™. However, no “designated” monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply PersulfOx™. This will avoid premature conclusions that the entire site meets cleanup goals. By making sure that designated tracking wells are not also used for treatment, there will be more assurance that the treatment process has permeated the entire site and that it did not remain localized to the area immediately surrounding each injection well.
- e. Groundwater monitoring:
 - 1. Active remediation monitoring for contaminants of concern: During the period of active remediation, groundwater shall be monitored in accordance with the requirements set forth in Section 62-780.700, F.A.C., for the contaminants of concern.
 - 2. Post active remediation monitoring for contaminants of concern: At least one (1) year of quarterly post remediation groundwater monitoring for the contaminants of concern shall be conducted at a minimum of two (2) wells, one located in the area of highest contamination, the other at the downgradient edge of the contamination plume, pursuant to Section 62-780.750, F.A.C.
 - 3. Underground injection control monitoring: For Underground Injection Control purposes, when PersulfOx™ is injected, the groundwater must be monitored pursuant to Rule 62-520.310(8)(c), F.A.C., for the parameters discussed above in paragraph c.
- f. Underground Injection Control (UIC) inventory: Remedial Action Plans proposing injection-type aquifer remediation shall include information pursuant to Rules 62-528.630(2)(c)1 through 6, F.A.C., for the inventory purposes of the UIC program. Reviewers of those plans, upon issuance of an enforceable Remedial Action Plan Approval Order by the Department, must submit a completed copy of the “UIC Notification” to the UIC program in Tallahassee. The notification is currently located on the Internet at www.dep.state.fl.us/waste/categories/pcp/pages/innovative.htm.
- g. Operation:
 - 1. Avoidance of migration: For injection-type, in situ aquifer remediation projects, injection of PersulfOx™ shall be performed in such a way, and at such a rate and volume that no

undesirable migration of either the reagent or the contaminants in the aquifer results, pursuant to Rule 62-528.630(3), F.A.C.

2. Underground injection control operating permit: Although an operating permit is not required for aquifer remediation wells pursuant to Rule 62-528.640(1)(b), and 62-528.640(1)(c), F.A.C., since no movement of the contamination plume is expected to accompany the treatment process, the Department requests that the information items listed in Rule 62-528.640(1)(b), F.A.C., be considered and included in Remedial Action Plan proposals as a matter of good and thorough design practice. Briefly summarized, they are: quality of water in the aquifer; quality of the injected fluid; existing and potential uses of the affected aquifer; and well construction details.
- h. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order or a declaration of "No Further Action", injection wells shall be abandoned pursuant to Section 62-528.645, F.A.C. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory-tracking list.
- i. Open-pit applications: While open-pit application of PersulfOx™ is not an injection-type application, and notification of the Underground Injection Control Section therefore not required, the user of PersulfOx™ must still be mindful of groundwater quality. For open-pit applications, the Division of Waste Management suggests that groundwater in the application area be monitored for the same parameters that would be monitored had the application been an injection. These parameters are listed above in paragraph *c*.

SUPPLEMENTAL INFORMATION

- a. General: As indicated by Regenesis, PersulfOx™ is a mixture of sodium persulfate oxidizer and sodium silicate catalyst. The mixture is shipped as a "single-part" dry white powder that the user can apply directly to an excavation, or mix with water prior to injection as an aqueous solution in the concentration range of 5-20% by weight, with most applications anticipated to be at 10-15% by weight. PersulfOx™ incorporates a dual activation mechanism, beginning with alkaline activation at a pH of 11 or higher when the product is mixed with water, and then switching to activation by amorphous silica, which forms as the pH drops below a value of 9.
- b. Ingredients: The February 8, 2013 revision of Regenesis' Material Safety Data Sheet indicates that PersulfOx™, as-shipped, is a solid, free-flowing powder of 90% by weight sodium persulfate [Chemical Abstracts Service (CAS) number 7775-27-1] and 10% sodium silicate (CAS number 1344-09-8). The pH of a 10% solution ranges from approximately 7 - 11.5 at 25° centigrade.
- c. Dual activation: Initially, the alkalinity of the sodium silicate (a base of pH greater than 11) serves to activate (catalyze) the sodium persulfate component of PersulfOx™ in order to generate radicals for the destruction of contaminants. But as the base is consumed and acidic conditions of lower pH develop, activation by alkalinity becomes limited. When the pH decreases below 9, amorphous silica (silicon dioxide), also a catalyst, is precipitated, and it continues to facilitate the formation of radicals at the lower pH for continued destruction of contaminants.

The precipitated amorphous silica is known as a heterogeneous catalyst because its solid phase differs from that of the liquid phase reactants (i.e., the contaminants being remediated). The mechanism of the catalysis is beyond the scope of this regulatory acceptance letter, but it is thought to involve surface-mediated reactions that include contaminant/catalyst adsorption, persulfate/catalyst interactions, and the adsorption of metals and metal oxides that may themselves also serve as catalysts. The Division of Waste Management sees no reason for PersulfOx™ to discriminate between the metals and metal oxides that may be naturally present at a treatment site and those that may be present per the assay of the sodium persulfate. Either way, a benefit is derived from the presence of metals and metal oxides that would otherwise play no role in the destruction of contaminants.