Florida Department of Environmental Protection

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August 3, 2015

Via Electronic Mail
Info@IRTechLLC.com

Mark Santangelo
Innovative Remediation Technologies, LLC
627 North Albany Ave., Suite 131
Chicago, Illinois 60612

Re: BIOX™

Dear Mr. Santangelo:

The Petroleum Restoration Program (PRP) hereby issues this superseding update of its earlier February 14, 2005 and September 29, 2009 acceptances of BIOX ™ for the remediation of petroleum and other suitable contaminants in groundwater and soil, in-situ and ex-situ. The BIOX ™ process itself has not changed, but the numbering of the Florida Administrative Code's regulatory rules has changed, as well as the name of the firm with which this acceptance is associated. Innovative Remediation Technologies, LLC was formerly BioManagement Sevices Incorporated. This acceptance applies to the regulatory jurisdiction of cleanups conducted pursuant to Chapter 62-780, Florida Administrative Code (F.A.C.).

BIOX ™ acts first as a chemical oxidation process, in the relatively neutral pH range of 7.0 to 8.5, with a minimal temperature rise of 5 °F or less, and then as a bioremediation process by providing nutrients and oxygen for the indigenous aerobic microorganisms at the remediation site.

The chemical oxidation aspect of the process is a Fenton-type reaction that uses peroxide and ferrous sulfate to produce hydroxyls. The source of the peroxide can be from any or a mixture of the following: liquid hydrogen peroxide, or solid compounds such as calcium peroxide, magnesium peroxide, and sodium percarbonate. The hydroxyls produced by the Fenton reaction break down the contaminants at a remediation site to intermediate compounds that are more easily degraded by the site's indigenous microorganisms. The ultimate degradation products of petroleum hydrocarbon contaminants are carbon dioxide and water, and the ultimate degradation products of chlorinated hydrocarbon contaminants are carbon dioxide, water, and chloride. Enclosure 1 shows the composition of BIOX ™; Enclosure 2 contains regulatory information; and Enclosure 3 contains supplemental information.

The PRP does not provide endorsement of specific or brand name remediation products or processes. It does, however, recognize the need to determine their acceptability in the context of environmental regulations, safety and the protection of public health. For that reason, the PRP issues an "acceptance" letter, not an approval. Such acceptance shall not be construed as a certification of performance, nor shall it be construed as approval for uses that are beyond its jurisdiction. Additionally, vendors, upon receipt of an acceptance, must market their product or process on its 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. The plan, however, must contain sufficient information about the product or process to show that it meets all applicable rules and regulations.

The PRP reserves the right to revoke its acceptance of a product or process if it has been falsely represented. Additionally, PRP 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 submitted for Department review and approval. Questions should be directed to Rick Ruscito at (850) 877-1133, extension 3722, or the e-mail address below.

Sincerely,

Rick Ruscito

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enc: (1) BIOX™ Composition
(2) Regulatory Information
(3) Supplemental Information

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History:

2/14/05	ppl #257	inn_123	burlab # n/a
9/29/09	ppl #376	inn_123a	burlab #1288
8/3/15	ppl #504	inn_123b	burlab #1507

ENCLOSURE 1

BIOX™ COMPOSITION †

Iron, Fe	100 mg/L ▲
Sulfur, S	8,887 mg/L
Nitrogen, N	2,592 mg/L
Phosphorus, P	9,362 mg/L
Sodium, Na	6,417 mg/L
Calcium, Ca	35,297 mg/L
Magnesium, Mg	33,707 mg/L
Potassium, K	8,263 mg/L
Oxygen, O §	125,943 mg/L
Carbon, C	1,285 mg/L

† Maximum concentrations expected in BIOX fluids to be injected.

▲ mg/L (milligrams per liter)

§ Elemental oxygen, not the diatomic molecule.

ENCLOSURE 2

REGULATORY INFORMATION

a. Rules: The BIOX ™ process shall comply with all applicable regulations. This includes meeting applicable groundwater cleanup target levels during the timeframe of a cleanup project for the contaminants of concern, the residual concentrations of BIOX ™ reagents, and any byproducts of concern produced by chemical and biological reactions induced by those reagents.

   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 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C., for groundwater classes and standards; Chapter 62-522, F.A.C., for groundwater permitting and monitoring requirements; Chapter 62-528, F.A.C., for underground injection control, particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapters 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. Pilot study: Pursuant to rule 62-770.700(2), F.A.C., prior to performing a pilot study, a Pilot Study Work Plan must be submitted to the Department for review. If conditions at a site do not warrant a pilot study, or the area of contamination at a site is so small that the scale of a pilot study would approach the scale of a full-scale system, then consideration should be given to foregoing the pilot test in favor of proceeding to the preparation of a full-scale Remedial Action Plan.

c. Underground Injection Control permit: Per Rule 62-528.630(2)(c), F.A.C., the issuance of an enforceable, site-specific Remedial Action Plan Approval Order by the Department for injection-type aquifer remediation constitutes the granting of a Class V injection well construction/clearance permit.

d. Underground Injection Control notification: Remedial Action Plans proposing in situ, 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 Underground Injection Control 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 Underground Injection Control inventory notification memorandum that conveys this information to the Underground Injection Control program.

e. Temporary injection zone of discharge (ZOD): Since the BIOX ™ fluid to be injected does not meet the minimum groundwater criteria of Chapter 62-520, F.A.C., and the drinking water standards of Chapter 62-550, F.A.C., it will be necessary to obtain permission for a temporary injection zone of discharge by way of Rule 62-520.310(8)(c), F.A.C., prior to its use at a cleanup site. ZOD permission is required for the following four parameters: ammonia nitrogen, iron, sodium, and sulfate. Permission for all four can be obtained by way of the rule. None require permission by way of variance.

In order to obtain ZOD permission, each site-specific Remedial Action Plan proposing the use of BIOX ™ must: (a) indicate that the concentrations of ammonia nitrogen, iron, sodium, and sulfate in the fluid to be injected will be in excess of their groundwater standards; (b) specify a temporary injection zone of discharge size; (c) specify the period of time for which the temporary zone of discharge will be needed; and (d) propose groundwater monitoring of the four ZOD parameters. In most cases, monitoring on a quarterly basis should be sufficient. The number of monitoring wells to be sampled will depend on the size of the area treated with the BIOX ™, but for most applications, a minimum of two (2) wells should suffice: one in the center of the treatment area, the other near the downgradient edge.

The current groundwater standards for the BIOX ™ zone of discharge parameters are ammonia nitrogen [2.8 milligrams per liter (mg/L)]; iron (0.3 mg/L); sodium (160 mg/L); and sulfate (250 mg/L). Upon expiration of the time requested for the ZOD, each of these four parameters must meet their respective groundwater standard, or their natural-occurring background value at the site, whichever is less stringent.

The issuance of a site-specific Remedial Action Plan Approval Order for a Remedial Action Plan that meets the requirements of Rule 62-520.310(8)(c), F.A.C., constitutes the granting of permission for the temporary injection zone of discharge.

f. Utilization of wells: If a remediation site happens to have an abundance of monitoring wells, there is no objection to the use of some wells for the application of BIOX ™ reagents, provided no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply BIOX ™ reagents. 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.

g. Additives: If in the future either Innovative Remediation Technologies, LLC or a user of the BIOX ™ Process decides to augment it with other nutrients and/or chemicals, then the injection of such nutrients and other chemicals into an aquifer must also be in accordance with the underground injection control requirements of Chapter 62-528, F.A.C., which requires that substances injected meet the drinking water standards set forth Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapter 62-520, F.A.C. If the chemical composition of an additive is such that it cannot meet the injection requirements, then it will first be necessary to obtain permission for a temporary injection zone of discharge.

h. Avoidance of migration: For injection-type in situ aquifer remediation projects, injection of BIOX ™ reagents shall be performed in such a way, and at such a rate and volume, that no undesirable migration of either the reagents or the contaminants of concern in the aquifer results, pursuant to Rule 62-528.630(3), F.A.C.

i. 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 petroleum contamination plume is expected to accompany the treatment process, the items listed in Rule 62-528.640(1)(b), F.A.C., should 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. Additionally, each Remedial Action Plan should clearly indicate the total volume of the BIOX ™ reagents that will be injected.

j. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order, injection wells shall be abandoned pursuant to Section 62-528.645, F.A.C., and the Underground Injection Control program shall be notified so that they can be removed from the injection well inventory-tracking list.

k. Phosphate: This element, which is essential for life, occurs naturally in Florida's groundwater and is not a regulated groundwater contaminant. At a Panama City, Florida site, total phosphorus in the groundwater was measured at 800 to 1,100 micrograms per liter (ug/L). At a Volusia County site in Florida, it was measured at 1,200 ug/L, as PO_4. For comparison purposes, the European Community Guide level for phosphorus in drinking water is 400 ug/L, as P_2O_5. While phosphorus may not be a matter of great toxicological concern for in situ injection-type groundwater remediation projects, the Petroleum Restoration Program would like to remind users of the BIOX ™ Process that it could become an environmental concern if surface water is very close or present at a remediation site. In that case, if there could be any interaction between the groundwater being remediated and the nearby surface water body, then the state's surface water regulations should be reviewed first for information about phosphorus.

l. Open-pit applications: While open-pit applications of BIOX ™ reagents is not an injection-type application, and notification of the Underground Injection Control program therefore not required, the user of BIOX ™ must still be mindful of groundwater quality. For open-pit applications, the groundwater in the application area should be monitored for the same parameters that would have required monitoring had the application been an injection: ammonia nitrogen, iron, sodium, and sulfate.

ENCLOSURE 3

SUPPLEMENTAL INFORMATION

a. Dosage and application rate: It is recommended that the dosage and application details of the BIOX ™ Process be determined on a site-specific basis, but for information and planning purposes, the following may be helpful:

- Delivery methods: Injection, open-pit application, or overspraying
- Injection delivery: 1.25-inch diameter direct-push at 2-foot depth intervals
- Injection rate and pressure: 3 to 5 gallons per minute; 30 to 200 pounds per sq. in.
- Injection spacing: 3 to 7 feet for free product or high contaminant concentrations, 10 to 15 feet for low contaminant concentrations
- Number of injections: One or more may be necessary, depending on conditions

b. Oxidation reaction: In the first step of the BIOX ™ treatment process, reagents partially oxidize contaminants in order to produce intermediates that are more readily biodegradable in the second step. Unlike a conventional Fenton reaction, the BIOX ™ Process is not highly exothermic; it generates minimal heat, and does not need to occur at low pH.

c. Degradation products: Carbon dioxide and water are the ultimate products of aerobic and most anaerobic biodegradations of petroleum hydrocarbons. The intermediate products may include simple acids, alcohols, and fatty acids. Aerobic processes use oxygen as an electron acceptor to produce the carbon dioxide and water.

d. Indicator parameters and the frequency of their measurement: Information has been provided about indicator parameters of interest during the BIOX ™ treatment process, and the frequency of their measurement. Pre-treatment baseline sampling no earlier than 30 days prior to BIOX ™ application is recommended, and post-treatment sampling is recommended at 30, 60 and 90 days as follows:

Soil Analytical Parameters	Groundwater Analytical Parameters
Contaminants of Concern (COC)	COC
Chemical Oxygen Demand (COD)	COD
Biological Oxygen Demand (BOD)	BOD
Total Organic Carbon (TOC)	TOC
Total Heterotrophic Plate Count	Total Heterotrophic Plate Count
	Dissolved Oxygen (DO)
	Oxidation-Reduction Potential (ORP)

These indicator parameters are useful as follows:

- Declining trends in the TOC of soil and concomitant increasing trends in the groundwater can be indicative of the extent of desorption caused by the BIOX ™ process.
- Comparison of pre- to post-treatment COD and BOD of soil allows for assessment of the transformation of the soil organic matter, including contaminants, to more biodegradable species.
- Increasing trends in COD and BOD of groundwater are also indicative of desorption processes.
- Comparison of pre- to post-treatment COD and BOD of groundwater allows for the assessment of the biodegradability of the dissolved organic fraction.
- Comparison of trends in post-treatment BOD/COD ratios for soil to trends in post-treatment BOD/COD ratios for the groundwater allows for assessment of the effectiveness of enhanced biodegradation and bioavailability of contaminants over time.
- Analysis of trends in dissolved oxygen concentration, heterotrophic plate counts and biodegradability indicators (BOD, COD, BOD/COD ratio) can be used to derive limiting factors for natural and enhanced biodegradation of a cleanup site.