Florida Department of Environmental Protection
Bob Martinez Center
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Charlie Crist
Governor

Jeff Kottkamp
Lt. Governor

Michael W. Sole
Secretary

July 27, 2007

Mark A. Martin
Arrius Environmental Incorporated
315 Mac Brae Road
Louisville, Kentucky 40214

Re: **Groundwater and Soil Oxidant (GASOx)**

Dear Mr. Martin:

The Florida Department of Environmental Protection hereby accepts GASOx for the remediation of hydrocarbons, chlorinated hydrocarbons and other suitable contaminants in groundwater and soil, in situ and ex situ. As Arrius Environmental Incorporated has indicated, GASOx is a reactive, aqueous salt mix of peroxygens and sulfur oxides that destroy contaminants via chemical oxidation, without the aid of a catalyst, and without a vigorous reaction. The end products are carbon dioxide and water when hydrocarbons are treated. When chlorinated hydrocarbons are treated the end products include chlorine and chloride ions. It should be noted that GASOx is not a gas, as the acronym for Groundwater and Soil Oxidant may at first seem to imply, but rather a remediation product applied as an aqueous mix.

This acceptance applies only to the regulatory jurisdiction of the Florida Department of Environmental Protection. Other state agencies and local governments may choose to recognize this acceptance if their needs and regulations are similar. The Department, however, is not responsible for applications beyond its jurisdiction. Cleanup target levels established by the Department for a comprehensive list of specific soil and groundwater contaminants are set forth in Chapter 62-777, Florida Administrative Code (F.A.C.), and additional information about petroleum contamination site cleanup criteria can be found in Chapter 62-770, F.A.C.

For soil remediation at sites where the underlying groundwater will not be affected by the leaching of GASOx ingredients, the soil cleanup criteria of Chapter 62-777, F.A.C., apply to both the contaminants of concern at the site and any "ingredients and parameters of concern" in the GASOx itself. But for injection-type, in situ groundwater remediation via direct injection of GASOx into an aquifer, or into the soil at a depth (or under conditions) where GASOx ingredients could leach or percolate into the underlying groundwater, there are underground injection control regulations that must be observed. Since in situ, injection-type aquifer remediation is likely to be the most common application of GASOx, the bulk of the regulatory requirements discussed herein will be directed to that topic.

There are no objections to the use of GASOx for the remediation of contaminants in Florida provided: (a) the considerations of this letter are taken into account; (b) a site-specific Remedial Action Plan is submitted to the Department, for approval, for each site where the use of GASOx is proposed; and (c) the Remedial Action Plan meets the requirements of Rule 62-522.300(2)(c), F.A.C., in order to receive permission for a temporary injection zone of discharge for pH, sulfate and total dissolved solids. Enclosure 1 is a voucher for the confidential disclosure of proprietary GASOx ingredients, and Enclosure 2 provides regulatory information.

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, however, upon receipt of an acceptance, must still market their product or process on its own merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace. Additionally, the Department emphasizes that this is a regulatory acceptance, not an approval, and in no way shall it be construed as Department certification of performance.

Also, 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 and appropriate rules and regulations.

Those who prepare Remedial Action Plans are advised to include a copy of this letter in the appendix of their plans. In this way, technical reviewers will be informed that you have contacted the Department of Environmental Protection to inquire about the environmental acceptability of GASOx. To aid those reviewers, supplemental information is provided in Enclosure 3.

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. You may contact me at (850) 877-1133, extension 3722, if there are any questions.

Sincerely,

Rick Ruscito

Rick Ruscito, P.E.
Ecology and Environment, Inc.
Bureau of Petroleum Storage Systems
Petroleum Cleanup Section 6

Rebecca S. Lockenbach

Rebecca S. Lockenbach
FDEP Section Leader
Bureau of Petroleum Storage Systems
Petroleum Cleanup Section 6

c: Tom Conrardy - FDEP/Tallahassee

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ENCLOSURE 1

Florida Department of Environmental Protection

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July 27, 2007

Mark A. Martin
Arrius Environmental Incorporated
315 Mac Brae Road
Louisville, Kentucky 40214

Re: **Voucher for Disclosure of Proprietary Ingredients in Groundwater and Soil Oxidant (GASOx)**

Dear Mr. Martin:

The Florida Department of Environmental Protection hereby acknowledges confidential disclosures by Arrius Environmental Incorporated, dated July 9, 2007 and July 17, 2007, identifying the proprietary ingredients of GASOx, a reactive, aqueous salt mix of peroxygens and sulfur oxides that destroy contaminants via chemical oxidation. GASOx can be used for the remediation of hydrocarbons, chlorinated hydrocarbons and other suitable contaminants in groundwater and soil. Having reviewed the disclosure, the Department vouches for the identity of the ingredients.

Without divulging any proprietary aspects of the product, the Department hereby provides the minimum amount of information necessary for users of GASOx to comply with the requirements of Rule 62-522.300(2)(c), Florida Administrative Code (F.A.C.). This rule requires that a Remedial Action Plan for in situ, injection-type aquifer remediation indicate the size and duration of a temporary injection zone of discharge that is needed for any chemical species or physical properties in the fluid to be injected that do not meet the State of Florida's primary and secondary groundwater standards and minimum groundwater criteria. The rule also requires that the plan provide for groundwater monitoring of those chemical species and physical properties. In the case of the GASOx, the chemical species and physical properties to be monitored are total dissolved solids, sulfate and pH. Per the rule, Department-approval of the Remedial Action Plan constitutes permission for the temporary injection zone of discharge.

For underground injection control purposes, in situ injection-type aquifer remediation plans must indicate the composition and volume of the fluid to be injected. Since the ingredients of GASOx are proprietary, it will suffice to indicate just the overall concentration of GASOx and the volume to be injected, and provide a footnote indicating that one-time confidential disclosures dated

July 9, 2007 and July 17, 2007, identifying the proprietary ingredients, have already been submitted to the Florida Department of Environmental Protection.

This voucher is issued solely for the purposes of the Florida Department of Environmental Protection. Other state agencies and local governments may choose to recognize this voucher if their needs are similar. The Department, however, is not responsible for applications beyond its jurisdiction. Please direct questions regarding this voucher to Rick Ruscito at (850) 877-1133, extension 3722.

Sincerely,

Rick Ruscito

Rick Ruscito, P.E.
Ecology and Environment, Inc.
Bureau of Petroleum Storage Systems
Petroleum Cleanup Section 6

Rebecca S. Lockenbach

Rebecca S. Lockenbach
FDEP Section Leader
Bureau of Petroleum Storage Systems
Petroleum Cleanup Section 6

REGULATORY INFORMATION

a. Groundwater cleanup standards: The onus shall be on users of GASOx to ensure that all applicable groundwater contaminant standards will be met at the time of project completion, for the contaminants of concern at the cleanup site, any residuals associated with the ingredients of GASOx, and any byproducts 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 minimum criteria; 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; Chapter 62-770, F.A.C., for petroleum cleanup criteria; and Chapter 62-777, F.A.C., also for cleanup and minimum groundwater criteria.

   A noteworthy aspect of the minimum criteria set forth in Chapter 62-520, F.A.C., is that it requires groundwater to be free from substances that are harmful to plants, animals, and organisms, and free from substances that are carcinogenic, mutagenic, teratogenic or toxic to human beings. In effect, these "free from" requirements form a catchall. They close what would otherwise be a loophole in the regulations by preventing introduction of a potentially harmful product in the event that any of its ingredients is not regulated as a specific primary or secondary drinking water contaminant.

b. Injection well permit: The issuance of a site-specific Remedial Action Plan Approval Order by the Florida Department of Environmental Protection for in situ, injection-type aquifer remediation 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. Groundwater injection standards: For 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 groundwater criteria of Chapter 62-520, F.A.C., pursuant to underground injection control Rule 62-528.600(2)(d), F.A.C. Aquifer remediation fluids that do not meet these requirements must seek permission for a temporary injection zone of discharge. Depending on the ingredients of the fluid, it will be necessary to obtain an injection zone of discharge by either one or both of the following methods: by Rule 62-522.300(2)(c), F.A.C., or by variance from Rule 62-522.300(3), F.A.C. For GASOx injection, only Rule 62-522.300(2)(c), F.A.C., needs to be observed in order to be permitted an injection zone of discharge for pH, sulfate and total dissolved solids.

d. Temporary injection zone of discharge by rule: For the injection of GASOx , Rule 62-522.300(2)(c), F.A.C., requires that a site-specific Remedial Action Plan proposing its use: (a) indicate that pH, sulfate and total dissolved solids in the fluid to be injected will be in excess of their groundwater injection standards; (b) specify the size of the temporary injection zone of discharge that is needed (typically expressed as a radius of influence for each injection point); (c) specify the period of time for which the temporary zone of discharge will be needed; and (d) propose groundwater monitoring of pH, sulfate and total

dissolved solids. The current groundwater standard for pH is range 6.5 to 8.5; the current standard for sulfate is 250 milligrams per liter (mg/L); and the current standard for total dissolved solids is 500 mg/L. If the groundwater's natural-occurring background level for any of these parameters at a specific remediation site does not meet the established standard, then the residual level of that parameter by the time remedial action ends shall be no worse than the pre-existing background level. In cases where chlorinated hydrocarbons are being treated, it is suggested that the groundwater also be monitored for chloride --- albeit chlorine is not an ingredient of GASOx but rather a contaminant degradation byproduct. The groundwater standard for chloride is 250 mg/L.

e. Utilization of wells: If a remediation site happens to have an abundance of monitoring wells, then the Department has no objection to the use of some wells for the application of GASOx. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply GASOx 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.

f. Groundwater monitoring:

1. Active remediation monitoring: For petroleum cleanup projects, during the period of active remediation, groundwater shall be monitored in accordance with the requirements of Section 62-770.700, F.A.C., for the petroleum hydrocarbon chemicals of concern. For non-petroleum cleanup projects, the monitoring shall be in accordance with the approved Remedial Action Plan.

2. Post remediation monitoring: For petroleum cleanup projects, pursuant to Section 62-770.750, F.A.C., at least one (1) year of quarterly post active remediation groundwater monitoring shall be conducted for the petroleum chemicals of concern. For non-petroleum cleanup projects, the monitoring shall be in accordance with the approved Remedial Action Plan.

3. Underground injection control monitoring: For Underground Injection Control purposes, when GASOx is injected, the groundwater must be monitored for pH, sulfate and total dissolved solids, pursuant to Rule 62-522.300(2)(c), F.A.C. In most cases, monitoring on a quarterly basis should suffice.

g. Underground injection control inventory: Remedial Action Plans proposing, in situ, injection-type aquifer remediation shall include information pursuant to Rule 62-528.630(2)(c)1 through 6, F.A.C., for the inventory purposes of underground injection control. Per Rule 62-528.630(2)(c), F.A.C., aquifer remediation projects involving injection wells may be authorized under the provisions of a Remedial Action Plan, provided the construction, operation, and monitoring requirements of Chapter 62-528, F.A.C., are met. A memorandum outlining the inventory information about injection-type aquifer remediation

plans to be transmitted by Department reviewers to the Underground Injection Control Section is provided as Enclosure 4. Only the Department, including its district offices, may approve in situ injection-type remediation plans in which the approval constitutes a Class V injection permit; local programs are not authorized to grant such approvals. See Enclosure 3.

h. Operation:

1. Avoidance of migration: For in situ, injection-type aquifer remediation projects, injection of GASOx 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 petroleum contaminants in the aquifer results. [Rule 62-528.630(3), F.A.C.]

2. Underground injection control operating permit: Although an operating permit is not required for injection-type 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. Additionally, <u>each Remedial Action Plan should clearly indicate the total volume and overall concentration of the GASOx that will be injected</u>.

i. 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. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory-tracking list.

j. Open-pit applications: While open-pit application of GASOx is not an injection-type application, and notification of the Underground Injection Control Section therefore not required, the user of GASOx must still be mindful of groundwater quality. For open-pit applications, the Florida Department of Environmental Protection suggests that groundwater in the application area be monitored for the same parameters that would be monitored had the application been an injection. Sampling on a quarterly basis should suffice in most cases.

SUPPLEMENTAL INFORMATION

a. Department of Environmental Protection reviewers of in situ, injection-type aquifer remediation plans, regardless of whether in Tallahassee or district offices, must fill in the blanks on the Enclosure 4 memorandum, whose subject is "Proposed Injection Well(s) for In situ Aquifer Remediation at a Remedial Action Site". The completed form must be submitted to the Underground Injection Control Section at 2600 Blair Stone Road, Tallahassee, Florida 32399-2400 (Mail Station 3530).

   Only the Department and its district offices may approve in situ, injection-type aquifer remediation plans in which the approval constitutes the issuance of a Class V injection permit. Local programs are not authorized to grant such approvals. Reason: Although an arrangement between the Environmental Protection Agency and the Department delegates underground injection control authority to the Department, it does not allow the Department to delegate that authority any further. This includes delegation to the Department's contracted remediation review agencies such as those operated by the counties and other local governments. Local contracted programs, however, can still review injection-type aquifer remediation plans, and arrange for Department issuance of approval orders using the same administrative mechanism by which the Department issues Remedial Action Plan Approval Orders for their non-injection-type Remedial Action Plan reviews.

b. Pilot study: Per 62-770.700, Florida Administrative Code (F.A.C.), a pilot study proposal shall be submitted for review, and a pilot test shall be performed prior to designing a full-scale treatment system. If conditions or the situation at a site do not warrant a pilot study, then a proposal explaining the rationale for the decision not to perform a pilot study shall be submitted for review.

c. GASOx injection concentration: Arrius Environmental Incorporated indicates that the typical overall concentration of GASOx reagents in the fluid to be injected is 5% to 10%, although concentrations as high as 28% are achievable, depending on mixing ratios and water temperature.

d. No additional acid is used: The decrease in aquifer pH when GASOx is injected is due to the GASOx reagents themselves. Acids are not added to lower the pH.

e. Injection methods: The introduction of GASOx to an aquifer for remediation purposes is typically a gravity-feed injection. Other methods are feasible, including recirculating/re-injection and recirculating/re-infiltration.

f. Injection wells: Arrius Environmental Incorporated indicates that direct-push technology may not be suitable for the application of GASOx in tight clays, but it can be considered for sandy lithologies. As for materials of construction for the injection wells, PVC, CPVC and stainless steel have been used successfully. The mixing tanks are HDPE.

g. Other application methods: The application of GASOx is not limited to just injection. Land farming has been done on a pilot scale, and application of dry GASOx reagents to the bottom of an open pit can be used for remediation of the smear zone.

h. Free product: Arrius Environmental Incorporated indicates that GASOx has been used at sites where free product is present. It has been found to be more effective to install injection wells at the perimeter of the free product area, and use those wells with low concentrations of GASOx to mobilize the free product to a central area of well, where it can be collected using either a vacuum or recovery pump. The perimeter wells create a cone of impression, and the resulting gradient pushes the free product toward the central collection point.

i. Safety reminders: Even though GASOx is formulated to produce a non-vigorous reaction, it does not minimize the need for safety. Safety considerations to be kept in mind include but are not necessarily limited to the items below

- Use of proper protective clothing.
- Oxidation is an exothermic reaction.
- Use storage containers, tanks and piping constructed from materials that are compatible with the oxidizer being used.
- Proper disposal of unused or unwanted GASOx.

Additional safety items to consider for chemical oxidation-type remediation processes are listed in the Florida Department of Environmental Protection's Remedial Action Plan checklist.

Memorandum **Florida Department of Environmental Protection**

TO: Richard Deuerling, Mail Station 3530
Division of Water Resource Management
Underground Injection Control Section
Florida Department of Environmental Protection
2600 Blair Stone Road, Tallahassee, FL 32399-2400

FROM: _____ [see Note 1.]
_____
_____

DATE: _____

SUBJ: **Proposed Injection Well(s) for In Situ Aquifer Remediation at a Remedial Action Site**

Pursuant to paragraph 62-528.630(2)(c), F.A.C., inventory information is hereby provided regarding the proposed construction of temporary injection well(s) for the purpose of in situ aquifer remediation at a contaminated site.

Site name: _____
Site address: _____
City/County: _____
Latitude/Longitude: _____
FDEP Facility Number: _____

Site owner's name: _____
Site owner's address: _____
_____
_____
_____

Well contractor's name: _____ [see Note 2.]
Well contractor's address: _____
_____
_____
_____

Brief description of the in situ injection-type aquifer remediation project:
_____
_____

Site name: _____
FDEP Facility No.: _____

Summary of major design considerations and features of the project:

Areal extent of contamination (square feet): _____
Number of injection wells: _____
Composition of injected fluid [see Note 3.]
(ingredient, wt. %): _____
_____
_____
_____
Injection volume per well (gallons): _____
Single or multiple injection events: _____
Injection volume total (all wells, all events): _____

A site map showing the areal extent of the groundwater contamination plume, and the location and spacing of injection wells and associated monitoring wells is attached.

The following is a summary description of the affected aquifer:

Name of aquifer: _____
Depth to groundwater (feet): _____
Aquifer thickness (feet): _____

The injection well(s) features are summarized below, and/or a schematic of the injection well(s) is attached.

Direct-push or HSA/Mud rotary *(circle the appropriate well type)*
Diameter of well(s) (i.e., riser pipe & screen) (inches): _____
Total depth of well(s) (feet): _____
Screened interval: _____ to _____ feet below land surface
Grouted interval: _____ to _____ feet below land surface
Casing diameter, if applicable (inches): _____
Cased depth, if applicable: _____ to _____ feet below land surface
Casing material, if applicable: _____

The in situ injection-type aquifer remediation plan for this contaminated site is intended to meet the groundwater cleanup criteria set forth in Chapter 62-777, F.A.C. Additionally, all other groundwater standards will be met at the time of project completion for any residuals associated with the ingredients of the injected remediation products, and any by-products or intermediates produced as a result of the chemical or biochemical transformation of those ingredients or the contaminating petroleum during their use. Applicable primary and secondary drinking water standards are set forth in Chapter 62-550, F.A.C., and additional groundwater quality criteria are set forth in Chapter 62-520, F.A.C.

Site name: _____
FDEP Facility No.: _____

The remediation plan estimates that site remediation will take _____ months. We will notify you if there are any modifications to the remediation strategy which will affect the injection well design or the chemical composition and volume of the injected remediation product(s).

The proposed remediation plan was approved on _____ by an enforceable approval order. A copy is attached. The remediation system installation is expected to commence within 60 days. Please call me at _____ if you require additional information.

Note 1. Local programs are not authorized to approve underground injections into aquifers. Reason: Per agreement with the USEPA, the FDEP cannot delegate this authority. Local programs, after reviewing a Remedial Action Plan or an injection proposal document, should prepare the Approval Order and route it to Tallahassee for Bureau Chief's signature, and then complete this form. This form is primarily for use by state and local program technical reviewers, but remediation contractors may fill in all blanks except those labeled "FROM" and "DATE" on page 1, and the approval date and telephone number blanks in the last paragraph. Those blanks should be completed only by a state or local program reviewer.

Note 2. If an injection well installation contractor has not yet been selected, then indicate the name and address of the project's general remediation contractor/consultant.

Note 3. Complete chemical analysis of injected fluid is required by Chapter 62-528, F.A.C. Proprietary formulations shall make confidential disclosure. Injected fluids must meet drinking water standards of Chapter 62-550, F.A.C., unless a zone of discharge is permitted by way of rule 62-522.300(2)(c), F.A.C., or a variance.