



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

June 4, 2007

Will Craven
Virotec AquaSolve™
2414 Jefferies Highway
Walterboro, South Carolina 29488

Re: **Arsenic ProActiv™**

Dear Mr. Craven:

The Florida Department of Environmental Protection (the Department) hereby accepts Arsenic ProActiv™ as an in situ groundwater remediation product for the immobilization of dissolved arsenic and other suitable dissolved metals by chemical adsorption. It is used in conjunction with sodium persulfate or other suitable oxidizing agents, and is applied as a slurry. As Virotec AquaSolve™ has indicated, two major steps are involved. The first is performed by the sodium persulfate, converting the arsenite ion to the arsenate form. In the second step, the arsenate adheres to the Arsenic ProActiv™ solids by way of chemical adsorption (chemisorption) to form a non-leachable mineral solid. The chemical composition of Arsenic ProActiv™, as reported in its Material Safety Data Sheet, is shown in Enclosure 1.

There are no objections to the use of Arsenic ProActiv™ provided: (a) the considerations of this letter are taken into account; (b) a site-specific Remedial Action Plan is approved by the Department prior to its use; and (c) the requirements of Rule 62-522.300(2)(c), Florida Administrative Code (F.A.C.) are observed for sodium persulfate with respect to iron, manganese, pH, sodium, sulfate and total dissolved solids. Regulatory considerations are set forth in Enclosure 2.

While the Florida 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 must then market the products and processes on their own merits regarding performance, cost and safety against competing alternatives in the marketplace. In no way, however, shall this regulatory acceptance be construed as certification of product performance. Additionally, the Department emphasizes a distinction between its regulatory "acceptance" and an approval. Products and processes are accepted but they are not approved.

Will Craven
June 4, 2007
Page 2

Those who prepare Remedial Action Plans may include a copy of this letter in the appendix of plans they submit, and call attention to it in the text of their document. In this way, technical reviewers throughout the state will be informed that you have contacted the Department to inquire about the acceptability of Arsenic ProActiv™ with respect to environmental regulations. To aid those reviewers, the Department provides supplemental information as Enclosures 3, 4 and 5.

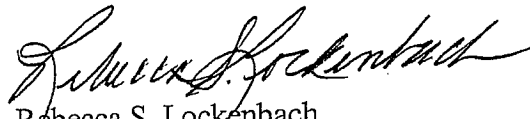
It is not a requirement that a remediation product or process hold an acceptance letter in order to be proposed in a site-specific Remedial Action Plan. The plan, however, must contain sufficient information about the product or process to show that it meets all applicable and appropriate rules and regulations.

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 Remedial Action Plans prescribing the product or process. You may contact me at (850) 877-1133, extension 3722 if there are any questions.

Sincerely,



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



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

- enc: (1) Arsenic ProActiv™ Chemical Composition
(2) Regulatory Information
(3) Supplemental Information
(4) Residuals Analysis
(5) Toxic Characteristic Leachate Procedure (TCLP) Analysis of Spent Material
(6) Underground Injection Control Memorandum

c: T. Conrardy - FDEP/Tallahassee

June 4, 2007

ENCLOSURE 1

ARSENIC PROACTIVE™ CHEMICAL COMPOSITION†

Chemical Name	CAS Number	Proportion
Iron oxyhydroxides (mainly hematite Fe_2O_3)	1309-37-1	28 – 35%
Hydrated alumina ($\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$)	1344-28-1	18 – 25%
Sodalite ($\text{Na}_4\text{Al}_3\text{Si}_3\text{O}_{12}\text{Cl}$)	1302-90-5	18 – 22%
Quartz (SiO_2)	14808-60-7	3 – 6%
Cancrinite ($(\text{Na}, \text{Ca}, \text{K})_8(\text{Al}, \text{Si})_{12}\text{O}_{24}(\text{SO}_4, \text{CO}_3)$)	12172-98-4	7 – 10%
Calcium carbonates & hydroxycarbonates	471-34-1	4 – 8%
Magnesium hydroxides & hydroxycarbonates	1309-42-8	2 – 3%
Titanium oxides	51745-87-0	4 – 6%
Trace inorganic elements		< 0.2%
Water		Balance

† Information from Material Safety Data Sheet dated July 2006 by Virotec U.S.A., P.O. Box 1914, Lenox Hill Station, New York 10021-1914.

ENCLOSURE 2

REGULATORY INFORMATION

- a. Groundwater regulations and cleanup standards: The onus shall be on users of Arsenic ProActiv™ in conjunction with sodium persulfate to ensure that all applicable groundwater standards will be met at the time of project completion for the contaminants of concern, any residuals associated with the constituents of Arsenic ProActiv™ and the sodium persulfate, and any byproducts produced as a result of chemical or biochemical reactions involving those constituents. The following chapters of the Florida Administrative Code 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; 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; and Chapter 62-777, F.A.C., for cleanup 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 injection 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 either the Bureau of Waste Cleanup, the Bureau of Petroleum Storage Systems, or other bureau or district office of the Florida Department of Environmental Protection, for remediation via injection of Arsenic ProActiv™ and sodium persulfate 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. Groundwater injection standards: For in situ aquifer remediation, pursuant to Chapter 62-528, F.A.C., 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 described in Chapter 62-520, F.A.C. The minimum groundwater criteria set forth in Chapter 62-777, F.A.C., also apply. The Department, having considered the chemical constituents and physical properties of Arsenic ProActiv™ and sodium persulfate, has determined that Arsenic ProActiv™ alone will meet groundwater injection standards but the following six parameters associated with the sodium persulfate oxidizing agent used in conjunction with it will not: iron, manganese, pH, sodium, sulfate and total dissolved solids. In order to use the sodium persulfate, it will be necessary to obtain permission for a temporary injection zone of discharge for these six parameters pursuant to Rule 62-522.300(2)(c), F.A.C., as described in paragraph *d* below each time a site-specific Remedial Action Plan is proposed.

- d. Temporary injection zone of discharge: Rule 62-522.300(2)(c), F.A.C., effective August 27, 2001, allows a temporary injection zone of discharge for aquifer remediation purposes, for primary standards of groundwater for closed-loop re-injection systems and for the prime constituents of the reagents used to remediate site contaminants, and for the secondary standards for groundwater. In order to comply with this rule, a Department-approved, site-specific remediation plan proposing the use of sodium persulfate in conjunction with Arsenic ProActiv™ must: (a) identify iron, manganese, pH, sodium, sulfate and total dissolved solids as the parameters whose groundwater standards could be exceeded, due to the sodium persulfate; (b) indicate the size and duration of the temporary zone of discharge; and (c) propose groundwater monitoring for those six parameters. In most cases, monitoring on a quarterly basis should suffice.

The Department would like to encourage those who prepare Remedial Action Plans to use a non-excessive duration time and zone size when complying with Rule 62-522.300(2)(c), F.A.C. Historically, in Florida, most temporary zones of discharge for injection-type aquifer remediation have been for a period of approximately one (1) year and a zone size in the range of 10 to 50 feet radially from each injection point.

- e. Additional sodium persulfate considerations: Virotec AquaSolve™, in reply to a Department inquiry, has indicated that the manufacturer of the sodium persulfate to be used in conjunction with Arsenic ProActiv™ is FMC Corporation. Additional information about FMC's sodium persulfate can be found in the February 25, 2005 acceptance letter by the Florida Department of Environmental Protection for the FMC product trade name Kloxür. As part of the Kloxür acceptance process, FMC provided to the Department an assay of this product.

Sodium persulfate from suppliers other than FMC Corporation can be used, but only if a complete chemical assay is provided. This is necessary for the identification of parameters that must be addressed pursuant to Rule 62-522.300(2)(c), F.A.C., in order to obtain permission for a temporary injection zone of discharge. There will always be at least four zone of discharge parameters associated with sodium persulfate, irrespective of the manufacturer: sodium, sulfate, pH and total dissolved solids. Whether there are other additional parameters will depend on the type of impurities that are indicated by the assay, and their concentration in the sodium persulfate solution to be injected at a remediation site. If the type and concentration of impurities are such that permission for a temporary zone of discharge cannot be granted by way of Rule 62-522.300(2)(c), F.A.C., alone, then it may be necessary to seek permission by way of a more involved petition for variance process.

- f. 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 Arsenic ProActiv™ and sodium persulfate. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply Arsenic ProActiv™ and sodium persulfate. 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. Groundwater monitoring:

1. Active remediation monitoring for contaminants of concern: Active remediation groundwater monitoring should be conducted in accordance with the provisions of an approved site-specific Remedial Action Plan for the contaminants of concern.
2. Post remediation monitoring for contaminants of concern: During the period of post active remediation, groundwater monitoring for contaminants of concern shall be conducted in accordance with the provisions of an approved site-specific Remedial Action Plan.
3. Monitoring of sodium persulfate parameters for underground injection control purposes: Pursuant to Rule 62-522.300(2)(c), F.A.C., the monitoring of iron, manganese, pH, sodium, sulfate and total dissolved solids must be addressed in a site-specific, Department-approved Remedial Action Plan that proposes the injection of the sodium persulfate in conjunction with the Arsenic ProActiv™.

h. Underground injection control inventory: Remedial Action Plans proposing injection-type, in situ aquifer injection-type 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 6.

i. Avoidance of migration: For injection-type, in situ aquifer remediation projects, injection of Arsenic ProActiv™ and the accompanying sodium persulfate shall be performed in such a way, and at such a rate and volume, that no undesirable migration of either the product's ingredients or the contaminants of concern in the aquifer results, pursuant to Rule 62-528.630(3), F.A.C.

j. 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.

k. Open pit applications: The addition of Arsenic ProActiv™ and sodium persulfate to an open excavation pit where the water table has been exposed is not an injection, and in such cases it is not necessary to notify the Underground Injection Control Section by using the

notification memorandum in Enclosure 6. However, this does not release the user from the responsibility of making sure that no long-term negative groundwater impacts occur as a result of the chemicals added to the pit. In the case of Arsenic ProActiv™ and sodium persulfate, it would be prudent to monitor iron, manganese, pH, sodium, sulfate and total dissolved solids in the exposed water. Monitoring on a quarterly basis should suffice in most cases. The water should also be sampled for these parameters prior to application of the chemicals, in order to establish their natural-occurring background levels at the site. In cases where the pit is to be backfilled immediately, the post application monitoring of these parameters can be accomplished by installing a sufficient number of monitoring wells in the former pit area. By the time the remediation project is completed, the monitoring of these parameters must show that they meet their respective Florida groundwater standards, or their natural-occurring background levels at the remediation site, whichever is less stringent.

1. Other oxidizing agents: In the event that an oxidizing agent other than sodium persulfate is to be used in conjunction with Arsenic ProActiv™, in order to convert the arsenite ion to the arsenate form, it will first be necessary to determine if a temporary injection zone of discharge must be established. To make the determination, the concentration of the oxidizer in the fluid to be injected must be known, and a complete chemical assay of oxidizer must also be provided. If injection of the oxidizer at the desired concentration meets the underground injection control criteria set forth in Chapter 62-528, F.A.C., then no zone of discharge needs to be established, and no special permission or monitoring is required. If the underground injection control criteria are not met by the oxidizer, then it will be necessary to determine if a temporary injection zone of discharge can be permitted by Rule 62-522.300(2)(c), F.A.C., or whether permission must be obtained by way of a more involved variance petition process.

ENCLOSURE 3

SUPPLEMENTAL INFORMATION

- a. Department of Environmental Protection reviewers of injection-type, in situ aquifer remediation plans, regardless of whether in Tallahassee or district offices, must fill in the blanks on the Enclosure 6 memorandum, whose subject is "Proposed Injection Well(s) for In Situ Aquifer Remediation at a Contaminated Site". The completed form must be submitted to the Underground Injection Control Section at 2600 Blair Stone Road, Tallahassee, Florida 32399-2400.
- b. Background and testing information: Arsenic ProActiv™ is made from Bauxsol™, a red mud residue from alumina refining. Bauxsol™ is a trade name based on the aluminum ore known as bauxite. It can also be described as a fine-grained, aluminum-depleted laterite, a mineral that is rich in iron and aluminum. A residuals analysis of Bauxsol™ is shown in Enclosure 4, and a toxic characteristic leachate (TCLP) analysis of spent Bauxsol™ is shown in Enclosure 5. The Bauxsol™ data shown in both of these enclosures is representative of Arsenic ProActiv™. From a regulatory standpoint, this data is of interest because it demonstrates that the product itself does not leave unacceptable concentrations of residuals in the water that it is intended to remediate, and that the product itself, once spent, is not classified as a hazardous waste.
- c. National Sanitary Foundation: Arsenic ProActiv™ is listed as a drinking water treatment chemical in NSF/ANSI Standard 60. The maximum use level for drinking water treatment purposes is limited to 1,000 milligrams per liter. For contaminated site remediation, however, where an aquifer has been contaminated to levels far worse than those of the source water for a drinking water treatment plant, the Department does not object to the use of higher dosages, as long as underground injection control regulations are not violated. As shown by Enclosure 4 residuals analysis, it appears that dosages as high as approximately 50 grams per liter can be tolerated.
- d. Variance petition withdrawn: Virotec AquaSolve™ originally submitted a petition for variance dated November 28, 2006 to the Florida Department of Environmental Protection, seeking permission for a temporary injection zone of discharge for the use of Arsenic ProActiv™ in conjunction with sodium persulfate in order to remediate contaminated aquifers. The Department, upon review of the petition and additional information submitted by Virotec AquaSolve™, determined that permission for a temporary injection zone of discharge did not have to be obtained by way of variance for the sodium persulfate component but could more easily be obtained by way of Rule 62-522.300(2)(c), F.A.C., and that a zone of discharge was not necessary at all for the metals present in Arsenic ProActiv™ component at the dosages to be injected. Virotec AquaSolve™, at the request of the Department, withdrew its petition for variance on April 6, 2007, and the

Department acknowledged the withdrawal and closed Office of General Counsel Case No. 06-2391 on May 14, 2007. As a prudent measure, however, a reminder is hereby provided to Virotec AquaSolve™ and potential users of Arsenic ProActiv™ to remain cognizant of Florida's underground injection control requirements, and to seek permission for a temporary injection zone of discharge in the future for any exceptional cleanup site where contaminant concentrations are so high as to warrant dosages of Arsenic ProActiv™ that no longer meet the state's underground injection control requirements.

- e. Dosage: The amounts of Arsenic ProActiv™ and sodium persulfate to be applied should be determined on a site-specific basis. It is recommended that prospective users contact Virotec AquaSolve™ for advice. But for the sake of providing at least a rough idea of the amounts involved, a representative concentration for the sodium persulfate component of the slurry to be applied can be considered to be approximately 10 percent by weight. For the Arsenic ProActiv™, the amount needed can be estimated using an adsorption ratio of approximately 50 grams of contaminate per kilogram of Arsenic ProActiv™.

June 4, 2007

ENCLOSURE 4

RESIDUALS ANALYSIS

Parameter	Concentration (milligrams per liter)
Aluminum	0.151
Barium	<0.001
Beryllium	<0.001
Boron	0.315
Cadmium	<0.01
Calcium	39
Chromium	0.007
Copper	0.001
Cyanide	<0.01
Hydrogen sulfide (as S^{2-})	0.005
Magnesium	17.6
Manganese	<0.001
Mercury	<0.001
Molybdenum	0.051
Nickel	0.001
Lead	<0.001
Potassium	10.5
Selenium	<0.001
Silica	27.4
Silver	<0.001
Sulfate	44.3
Uranium	0.002
Zinc	<0.001

Note 1. Residual chemical analysis of water treated using a 50-gram/liter dosage of Bauxsol™. Initial pH was 7.3, and initial concentration of arsenic was 1 gram/liter.

Note 2. Arsenic ProActiv™ is made from Bauxsol™, a red mud residue from alumina refining that has the ability to remove heavy metals.

Source: H. Genc, J.C. Tjell, D McConchie and O. Schuiling, *Journal of Colloid and Interface Science*, Volume 264, Number 2, August 15, 2003, pp. 327-334.

ENCLOSURE 5

TOXIC CHARACTERISTIC LEACHATE PROCEDURE (TCLP) ANALYSIS OF SPENT MATERIAL

Parameter	TCLP Result (milligrams per liter)
Antimony	0.001
Arsenic	<0.005
Barium	<0.001
Beryllium	<0.001
Cadmium	<0.001
Chromium	<0.001
Copper	0.002
Manganese	0.0065
Mercury	<0.001
Nickel	0.016
Lead	<0.001
Selenium	0.002
Silver	<0.001
Zinc	0.014

Note 1. Results of spent Bauxsol™ TCLP analyses conducted using acetic acid a pH 2.88.
Initial pH was 7.3, and initial concentration of arsenic was 1 gram/liter.

Note 2. Arsenic ProActiv™ is made from Bauxsol™, a red mud residue from alumina refining that has the ability to remove heavy metals.

Source: H. Genc, J.C. Tjell, D McConchie and O. Schuiling, *Journal of Colloid and Interface Science*,
Volume 264, Number 2, August 15, 2003, pp. 327-334.

Memorandum**Florida Department of
Environmental Protection**

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

FROM: _____

DATE: _____

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

Pursuant to Rule 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: _____ (Note 1.)

Well contractor's address: _____

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

Summary of major design considerations and features of the project:

Areal extent of contamination (square feet): _____

Number of injection wells: _____

Composition of injected fluid (Note 2)

(ingredient, wt. %): _____

Injection volume per well (gallons): _____

Single or multiple injection events: _____

Injection volume total (all wells, all
 events): _____

Richard Deuerling

Page Two

Date: _____

Site name: _____

FDEP facility no.: _____

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 Conventional (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 surface

Grouted interval: _____ to _____ feet below surface

Casing diameter, if applicable (inches): _____

Cased depth, if applic.: _____ to _____ feet below surface

Casing material, if applic.: _____

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 contaminants of concern 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.

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. 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 2. Complete chemical analysis of injected fluid is required by Chapter 62-528, Florida Administrative Code. Proprietary formulations shall make confidential disclosure. Injected fluids must meet drinking water standards of Chapter 62-550, F.A.C., unless an injection zone of discharge has been permitted by Rule 62-522.300(2)(c), F.A.C., or by variance.