



Department of Environmental Protection

Jeb Bush
Governor

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

David B. Struhs
Secretary

December 3, 2002

Mr. Michael D. Lee, Ph.D.
Terra Systems Incorporated
1053 Philadelphia Pike, Suite E
Wilmington, Delaware 19809

Re: **Emulsified Soybean Oil Lecithin (ESOL)**

Dear Mr. Lee:

The Florida Department of Environmental Protection hereby accepts Emulsified Soybean Oil Lecithin (ESOL) as a product for in situ anaerobic bioremediation of chlorinated hydrocarbons and other suitable contaminants in groundwater and soil. ESOL, a U.S. patented product, is an emulsion containing mostly soybean oil, lecithin, and water, with smaller amounts of yeast extract, sodium lactate, and a very small amount of sodium bromide as a tracer. With the exception of the sodium bromide tracer, the components of ESOL are either generally recognized as safe (GRAS) food-grade substances or already recognized by the Department as remediation reagents. Typical application rates are in the range of 100 to 500 gallons per injection point, although more or less may be required depending on site-specific conditions.

Although this acceptance applies only to the jurisdiction and the remediation needs of this Department, other state agencies and local governments may choose to recognize it if their needs and regulations are similar. This Department, however, is not responsible for applications beyond its jurisdiction.

For in situ groundwater remediation, via direct injection of ESOL into an aquifer, there are underground injection control (UIC) regulations that must be observed. Since in situ aquifer remediation via injection is likely to be the most common application of this product, the bulk of the regulatory requirements discussed herein will be directed to that topic.

The Department recognizes ESOL as a viable product for the bioremediation of contaminated sites in Florida. There are no objections to its use provided: (a) the considerations of this letter are taken into account; (b) a site-specific Remedial Action Plan is approved by the Department; and (c) a temporary zone of discharge variance from rule 62-522.300(3), Florida Administrative Code (F.A.C.) is obtained for total recoverable petroleum hydrocarbons (TRPH), due to the soybean oil, when the emulsion to be injected contains more than 5 milligrams per liter (mg/L) TRPH, which is the minimum groundwater criterion for TRPH per Chapter 62-777, F.A.C. Monitoring of groundwater before and after injection will be one of the terms of such a variance when granted.

For other components of ESOL that do not meet the underground injection control requirements of Chapter 62-528, F.A.C., rule 62-522.300(2)(c), F.A.C., applies. In order to comply with this rule, a Department-approved Remedial Action Plan proposing the use of ESOL must: (a) identify the primary and secondary drinking water standards that are not met by the ESOL fluid to be injected; (b) indicate the size and duration of a temporary zone of discharge for those primary and secondary drinking water parameters; and (c) address groundwater monitoring of

those primary and secondary drinking water parameters before and after injection. For ESOL, the primary and secondary drinking water parameters to be addressed pursuant to rule 62-522.300(2)(c), F.A.C. are total dissolved solids, sodium, and chloride (a by-product of the degradation of chlorinated hydrocarbons). For the small amount of sodium bromide tracer in ESOL (0.013%), the department will require that the groundwater be monitored before and after injection of ESOL for bromide.

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

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, especially those of the Florida Administrative Code.

Those who prepare Remedial Action Plans are advised to 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 of Environmental Protection to inquire about the environmental acceptability of ESOL. To aid those reviewers, the Florida Department of Environmental Protection provides environmental and regulatory information as enclosure 1. Enclosure 2 contains supplemental information about ESOL.

The Department reserves the right to revoke its acceptance of a product or process if its nature or performance 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 850/245-8911 if there are any questions.

Sincerely,

Rick Ruscito, P.E.
Division of Waste Management

ENCLOSURE 1

ESOL: ENVIRONMENTAL AND REGULATORY INFORMATION

For ESOL applications, the major environmental and regulatory considerations are provided below.

- a. Groundwater cleanup standards: The onus shall be on users of ESOL to ensure that all applicable groundwater standards will be met, at the time of project completion for chlorinated hydrocarbons and any other contaminants of concern, any residuals associated with the ingredients of ESOL, and any by-products produced as a result of chemical or biochemical reactions involving those ingredients. 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, 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; and Chapter 62-777, F.A.C., also for 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 which 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 the Florida Department of Environmental Protection, for remediation via injection of ESOL into an aquifer, constitutes the granting of the state's permit for a Class V injection well.
- 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., pursuant to underground injection control Rule 62-528.600(2)(d), F.A.C. A fluid that does not meet the injection standards of Chapter 62-528, F.A.C., may need to do either or both of the following, depending on its composition: (a) be granted a variance for a temporary zone of discharge; (b) comply with rule 62-522.300(2)(c), F.A.C.
- d. Variance parameter to be monitored: A variance, when granted by the Florida Department of Environmental Protection to Terra Systems Incorporated for a temporary zone of discharge for the injection of ESOL, at the least, will require groundwater monitoring of total recoverable petroleum hydrocarbons (TRPH) before and after the injection of ESOL, due to the soybean oil. Within the zone of discharge and the period of time specified by the variance, a temporary departure from the 5 milligram per liter minimum groundwater criteria set forth in Chapter 62-777, F.A.C., for TRPH will be tolerated when ESOL is injected for remediation purposes. By the end of the period, the groundwater must meet the required values for TRPH, or the natural-occurring background value for it at a given remediation site, whichever is less stringent.

If the variance granted by the Department is a general variance (i.e. not site-specific) then the variance is "portable" and may be applied to each

site-specific ESOL Remedial Action Plan submitted in the future. In this way, Terra Systems Incorporated does not have to petition for a new variance each time ESOL is proposed for the remediation of a site, provided there is no deviation from the terms of the variance.

- e. Other parameters to be monitored: Rule 62-522.300(2)(c), F.A.C., applies to ESOL and requires each Remedial Action Plan to address groundwater monitoring for the following parameters, which are listed along with their respective groundwater standards: total dissolved solids, 500 mg/L; chloride, 250 mg/L; and sodium, 160 mg/L. These parameters should be monitored before and after injection.

For the very small amount (0.013%) of sodium bromide tracer in ESOL, the groundwater shall be monitored for bromide before and after the injection of ESOL. The target concentration of bromide, by the completion of the remediation project, shall be 0.05 mg/L or less, which is the concentration of bromide in "source water" for drinking water systems. This target concentration qualifies drinking water systems for reduced bromide monitoring, pursuant to 40 CFR (Code of Federal Regulations), Part 141 - National Primary Drinking Water Regulations. Although the monitoring for bromide, and its 0.05 mg/L threshold concentration per National Primary Drinking Water Regulations, arises mainly as a concern for bromate (BrO_3^-) when ozone is used for disinfection, the Department reasons that this concentration should be a target for remediation sites as well. For information and comparative purposes, seawater contains approximately 65 mg/L bromine. Additionally, for information and comparative purposes, per 40 CFR Part 141, the national primary drinking water maximum contaminant level for bromate (BrO_3^-) is 0.010 mg/L. The Canadian interim maximum acceptable concentration for bromate in water as of January 1999 is also 0.010 mg/L.

- 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 ESOL. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply ESOL. 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. Additional nutrients: If, in the future, either Terra Systems Incorporated or a user of ESOL decides to augment ESOL with other nutrients and/or chemicals, 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 injected substances 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 ESOL is augmented with commercially available microorganisms, then those microorganisms shall be non-pathogenic.
- h. Underground injection control monitoring: Total recoverable petroleum hydrocarbons (TRPH) and any other chemical species covered by a zone of discharge variance granted for ESOL shall be monitored in accordance with the terms of such a variance, which are usually before and after injection, and includes the measurement of a site's natural-occurring background levels of those species. Additionally, for ESOL, per rule 62-522.300(2)(c), F.A.C., groundwater monitoring must be addressed in a Department-approved Remedial Action Plan for total dissolved solids, chloride, and sodium. Bromide shall be monitored as well.

The purpose of groundwater monitoring for ESOL chemical species before injection is to establish the natural-occurring background concentrations of those species at the site. The purpose of groundwater monitoring after injection is to show that the monitored ESOL parameters, by the time of project completion, meet their respective groundwater criteria or do not exceed their natural-occurring background levels, whichever is less stringent.

- i. Underground injection control inventory: Remedial Action Plans prescribing 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 3. Only the Department, including its district offices, may approve in situ injection-type remediation plans for which the approval constitutes a Class V injection permit; local programs are not authorized to grant such approvals. See enclosures 2 and 3.
- j. Operation:
 1. Avoidance of migration: For in situ injection-type aquifer remediation projects, injection of ESOL 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 already 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 ESOL 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, each Remedial Action Plan should clearly indicate the total volume of ESOL that will be injected.
- k. 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.

ENCLOSURE 2

ESOL: SUPPLEMENTAL INFORMATION

The information below, compiled from several sources, may be helpful to reviewers of Remedial Action Plans prescribing bioremediation.

- 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 3 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.

Only the Department and its district offices may approve in situ injection-type 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.

- b. Dosage and application rate: Terra Systems Incorporated indicates that the theoretical dosage of soybean oil, the key component of ESOL, is established by the electron demand of the contaminants to be dechlorinated. (ESOL is 10-20 percent soybean oil.) An example provided by Terra Systems is for perchloroethylene (PCE). One(1) gram of soybean oil will support the biodegradation of 7.9 grams of PCE. As indicated by Terra Systems, the biodegradation of 1 gram of the oil provides approximately 0.38 electron equivalents. One mole of perchloroethylene requires 8 electron equivalents or 0.048 electron/g PCE. If all the electrons from the soybean oil were used for PCE dechlorination, then 1 gram of the oil would support the biodegradation of 7.9 grams of PCE. The same reasoning applies to other contaminants to be degraded. The Department suggests that users of ESOL consult Terra Systems for the determination of dosages for site-specific conditions.

As for the application rate, Terra Systems indicates that a typical rate for ESOL is in the range of 100 to 500 gallons per injection point. For rule-of-thumb purposes only, ESOL applied to sand and gravel aquifers has had an observed radius of influence of at least 30 feet from the point of injection. The department suggests that users take into account their own site-specific conditions to determine if the radius of influence for their cleanup project will be more or less than 30 feet.

- c. Degradation products: Terra Systems Incorporated indicates that the long chain fatty acids in ESOL are degraded to simpler compounds such as acetic acid, propionic acid, and butyric acid by anaerobic bacteria. These compounds are further degraded to release hydrogen and electrons that are used by dechlorinating bacteria to remove chlorides, resulting in the production of relatively innocuous products such as ethane and ethene.
- d. Cleanup time: Like any other product or process, the cleanup time for ESOL depends on site-specific conditions, so no attempt will be made by the Department to present cleanup times as absolute. It was indicated

that chlorinated solvent contaminants at one site where ESOL was applied decreased to non-detect levels in as little as 3 months. Another site had a 66% reduction 16 months after a single application of ESOL, and a second application has since been applied to continue the cleanup. A barrier-type application of ESOL has also been underway now for 18 months, for which reductive dechlorination of trichloroethylene to cis-dichloroethylene has been observed, but further dechlorination to vinyl chloride and ethene or ethane has been limited. In this case, Terra Systems intends to force the dechlorination to completion by the introduction of bioaugmentation.

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: _____ (Note 1.)

DATE: _____

SUBJ: **Proposed Injection Well(s) for In Situ Aquifer
Remediation at a Remedial Action 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 2.)
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 3)
(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 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. Local programs are not authorized to approve underground injections into aquifers. Reason: Per agreement with EPA, the FDEP cannot delegate this authority. Local programs, after reviewing a Remedial Action Plan or an injection proposal document, should follow the instructions in a March 16, 2000 memorandum to arrange for Department headquarters' execution of an approval order, 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", "DATE", and "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, 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 exemption or variance has been granted.