



Patented *Injection Ready* 60% SRS[®]-FRL Large Droplet Emulsified Vegetable Oil (EVO) Substrate for Maximum Retention in the Aquifer

United States Patent #RE40,448

Terra Systems patented "*injection ready*" **60% SRS[®]-FRL** Large Droplet Emulsified Vegetable Oil Substrate is added to the groundwater to rapidly generate reducing conditions and provide the necessary carbon and hydrogen to support native or introduced microorganisms (*Dehalococcoides*) for the biodegradation of chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to innocuous end products including ethene and ethane.

Key Communication Points

- 60% SRS[®]-FRL is designed for use in aquifers with high groundwater flowrates (>180 ft/year), Fractured Rock Formations or Permeable Reactive Barriers (PRB's). It is also used for remediation treatment near streams, rivers and estuaries.
- The 5 µm droplet size results in better substrate retention in the subsurface.
- The anionic emulsifier (has a charge) results in better retention for the client because the substrate sticks more readily to the positively charged soil particles. It is specifically engineered to adhere to the formation, make contact with the bacteria and minimize the potential impact on nearby surface water.
- Provides 73% fermentable carbon.
- Has >98% biobased content.
- Includes sodium or potassium lactate to kick-start the anaerobic degradation process, nutrients and Vitamin B₁₂ a micronutrient, which *He et al. 2007* demonstrated is an important micronutrient to enhance dechlorination activity.
- It arrives as a homogenous ***injection ready substrate***, which results in lower field labor costs from inefficient field mixing.
- Proven effective with PCE, TCE, TECA, DNAPL (Sabre Project), Perchlorate, TCA, Cr⁶⁺, TNT, Uranium and Nitrate.
- Proven effective at military installations (Kelly AFB), dry cleaners, semiconductor manufacturers, fabricators and manufacturing firms that use and clean metal parts (air conditioners, dishwashers, etc.).

Table I: SRS[®]-FRL Large Droplet Emulsified Vegetable Oil Substrate Specifications

Ingredient	Percent	Description	Benefit
Food Grade U.S. Grown Soybean Oil	60%	Locally sourced soybean oil.	Long lasting slow release source of carbon and hydrogen.
Food Grade Soluble Substrate	5.5%	Rapidly biodegradable soluble substrate	Fast release source of carbon and hydrogen to rapidly generate anaerobic conditions
Proprietary Food Grade Nutrients	<1%	Proprietary organic and inorganic nutrients such	Nutrients have been demonstrated to support the growth of the anaerobic microbial

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		as yeast extract, nitrogen and phosphorus.	population.
Proprietary Food Grade Emulsifiers, Preservatives and other Organics	7.5%	Proprietary anionic emulsifier and other organics	Maximum retention in high groundwater flow-rate aquifers, fractured rock formations or permeable reactive barriers (PRB's) due to large droplet size and anionic emulsifier
Vitamin B ₁₂	<1%	250 µg/L of Vitamin B ₁₂	He et al. 2007 demonstrated Vitamin B ₁₂ to be an important micronutrient to enhance dechlorination activity with 25 µg/L providing maximum stimulation
Median Oil Droplet Size (microns)	NA	5 µm	Maximum retention in high groundwater flow-rate aquifers, fractured rock formations or permeable reactive barriers (PRB's). It is also used for remediation treatment near streams, rivers and estuaries.
pH	6.0 - 7	6.0 - 7	Optimum microbial activity
Organic Carbon (wt%)	73%		60% soybean oil and 13% from lactate, nutrients, emulsifiers and VB ₁₂
Zero Carbon Footprint	0%		Certified by The CarbonNeutral Co., SRS [®] has a carbon neutral footprint when it arrives at the job site.
Biobased Content	98%		Certified under USDA Biopreferred Program

Injection Ready Manufactured Emulsion

Terra Systems *Family* of patented SRS[®] emulsified vegetable oil substrates

- Arrives injection ready
- Nutrients are premixed into the SRS[®] during the manufacturing process - ensuring a homogenous substrate and avoiding the additional labor cost of mixing in the field
- Vitamin B₁₂ is premixed into the SRS[®] during the manufacturing process - ensuring a homogenous substrate and avoiding the additional labor cost of mixing in the field
- Sodium lactate, which kick starts the anaerobic process is premixed into the SRS[®] during the manufacturing process - ensuring a homogenous substrate and avoiding the additional labor cost of mixing in the field
- Arrives at the site with a zero-carbon footprint
- Certified under the USDA Biopreferred Program with >98% biobased content

Result: A consistent emulsified vegetable oil substrate, which arrives *ready to inject* for maximum retention in the aquifer.



It Avoids Field Mixing and Their Hidden Costs Such As:

- The cost of inadequate distribution due to variable droplet size and emulsion inconsistency
- The inability to accurately determine if you have 100% emulsification
- The lack of QA/QC in the field

Terra Systems QA/QC

Terra Systems owns and operates a state-of-the-art US based "*just-in-time*" manufacturing plant with an in-house quality control laboratory for strict quality assurance of the emulsion, droplet size and pH. A Microscope with "*Droplet Size Calculation Software*" calculates the "*mean*" droplet size for each batch of SRS[®]-SD before we transfer to a bucket, drum, tote or tanker for shipment to the customer. With every shipment, we include a QA/QC sheet for the actual batch that the customer receives. Included are:

- **Date Manufactured:** Freshly manufactured products have a longer shelf life in the field. Avoid buying substrates that have been stored for >1 month as fermentation can start and the pH will be negatively impacted.
- **pH:** We provide the pH of the product the day it is shipped
- **Droplet Size:** is a key measure of how effective the client can distribute the substrate in the subsurface.
- **Lot#'s for all the ingredients:** This is especially useful if the driller accidentally hits a discharge pipe and the consultant needs to provide documentary evidence of what exactly was injected to the regulatory agency. All of our ingredients are GRAS (generally recognized as safe).

Packaging: Terra Systems patented SRS[®] Family can be shipped in 5-gallon buckets, 55-gallon drums, 275-gallon IBC totes, 275-gallon cardboard totes or bulk tankers.

