SE
Georgia Environmental Protection Division 2 Martin Luther King Jr. Dr.
Land Protection Branch
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Response and Remediation Program
Atlanta, Georgia 30334
Response Development Units 1 – 3
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Name of Document:	EPD Comments: 2017 Progress Reports and Voluntary Remediation Plan
Date of Document:	November 16, 2017
Site Name:	Cessna Aircraft Company – Tax Parcel 112 003 002
Site ID Number:	Not Listed

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Signature: Philip T. Hendershot

Name (printed): Philip T. Hendershot

Date: 11/16/2017

Organization: CDM Smith

Receipt Date
(for EPD use only)

SE

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Document Submittal Form

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November 16, 2017

Mr. Kevin Collins
Manager – Unit Coordinator
Response and Remediation Program
Georgia Environmental Protection Division Land Protection Branch
2 Martin Luther King, Jr. Drive SE
Suite 1054, East Tower
Atlanta, Georgia 30334

Subject: EPD Comments: 2017 Progress Reports and Voluntary Remediation Plan
Cessna Aircraft Company – Tax Parcel 112 003 002
Columbus, Muscogee County, Georgia

Dear Mr. Collins:

CDM Smith and Cessna have reviewed the September 20, 2017 comments provided by the Georgia Environmental Protection Division (EPD) for the Semi-Annual Voluntary Remediation Program (VRP) Progress Reports #1 and #2 and the May 24, 2017 Voluntary Remediation Plan. Several of the comments were specifically related to the technical details of the proposed groundwater remediation in the Voluntary Remediation Plan and we have enclosed a Voluntary Remediation Plan Addendum in response to these comments. The remaining comments are addressed below.

Comment #1: The soil vapor extraction (SVE) system monitoring frequency is semi-annually and the results will be reported to EPD in the semi-annual progress reports. The primary performance monitoring criteria for the SVE system are to control the vapor intrusion potential by depressurization until that control is no longer needed, as indicated by monitoring the SVE system and groundwater. The VOC concentrations will be monitored during groundwater remediation and during SVE system operation. When the VOC concentrations fall below vapor intrusion screening levels and/or reach equilibrium, we will consider the viability of SVE system shutdown. Shutdown of the system will be followed by an indoor air sampling program before permanent SVE system shutdown is proposed.

Comment #2: Access to the Kemira Chemicals, Inc. property was requested on October 6, 2017, and the request included a focused investigation plan for the area immediately downgradient of Cessna, as shown on the enclosed Figure 1: Well & Stream Locations. Following an internal Kemira meeting, we were notified on October 24, 2017, that "Kemira does not agree to provide access to our property for CDM Smith's scope of work." CDM Smith has retained the records of these communications.

Because of the denied access to Kemira property, Cessna plans to implement the onsite groundwater remediation program described in the 2017 Voluntary Remediation Plan. An

updated implementation schedule is included in the enclosed Voluntary Remediation Plan Addendum.

If you have any questions or comments related to this letter or other related matters do not hesitate to contact me at (502) 217-7924 or by email at Hendershotpt@cdmsmith.com.

Sincerely,

Philip T. Hendershot, CHMM
Principal Environmental Scientist
CDM Smith Inc.

cc: David DuBose, EPD
Greg Simpson, Textron
Tom Duffey, CDM Smith

Enclosures

PLAN ADDENDUM

Remediation Plan Addendum

Cessna Aircraft Company GA1 Facility

Columbus, Muscogee County, Georgia

November 16, 2017

CDM Smith

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Appendices

Section 1
Introduction

This Voluntary Remediation Plan Addendum (Addendum) has been prepared by CDM Smith for the Cessna Aircraft Company (Cessna) GA1 facility in response to the Georgia Environmental Protection Division (EPD) comments dated September 20, 2017, that were related to the Voluntary Remediation Plan (CDM Smith, May 2017). These comments are listed below.

Comment: *EPD concurs, given the site access and logistical limitations, that a barrier technology may be a feasible groundwater remediation approach. However, at this time EPD does not recommend implementing the injections without access to the downgradient groundwater to surface water point of exposure (the creek), particularly regarding the risk of injectant daylighting and/or potential adverse effects to the creek. Please take these comments into account when designing the remediation actions for the site, and include details on what corrective measures will potentially be taken for surfacing of injection solution.*

Response: The injection of remediation solutions that are potentially mobile in groundwater will not be performed. The injections will be limited to emulsified vegetable oil (EVO) designed to adhere to the soil particles. These changes are identified in Section 4.2 and Section 5.

Comment: *Section 5.4.1 of the remediation plan states that injection wells will be installed to bedrock refusal, estimated at 35 feet below ground surface (bgs), with screened intervals from 15-35 feet. Based on the proposed injection well locations and the provided geologic cross-sections, the proposed depths and screened intervals will leave some of the well screen exposed above the water table. This may lead to preferential flow of the injected fluids into the unsaturated soils rather than deeper into the saturated zone where they are needed to contact the COC plume. Additionally, based on the borings from MW-3C, MW-A/B, and MW-7A/B, the bedrock surface appears to be deeper below the land surface to the south of the source area. For the down-gradient row of injection wells, please clarify if the wells will be installed to the bedrock surface or to a predetermined depth of 35 ft bgs.*

Response: The wells will not be installed to predetermined depths. The proposed injection well completion depths will be based on the location-specific hydrogeology, as determined in the field. The criteria to be used for injection well construction is provided in greater detail in Section 5.4.1.

Comment: *Section 5.2 of the report states that formation samples will be collected during injection well drilling and groundwater samples will be collected from monitoring well MW-3A and two new injection wells to determine dosing requirements for pH control. EPD recommends that groundwater samples be collected from the outermost injection wells and analyzed for VOCs to confirm that the width of the TCE RRS exceedance plume is contained within the injection barrier. EPD recommends that monitoring well MW-4A/B be added to the performance monitoring points proposed in section 5.6 to assess chemical parameters of the groundwater near the eastern edge of the injection barrier.*

Response: Section 5.6 has been revised to include initial sampling for volatile organic compounds (VOCs) from all injection wells and inclusion of MW-4A and MW-4B in the performance monitoring program.

Comment: *Section 5.4.3 describes the process of establishing reducing conditions in the injection area, and section 5.6 describes the parameters to be analyzed in subsequent performance monitoring events. EPD concurs with the parameters to be collected during quarterly sampling events to confirm that reducing conditions are maintained for adequate bioremediation. Please note that altering the oxidation/reduction conditions at the site has the potential to dissolve and mobilized metals that were previously immobile in stable mineral species or adsorbed to clay mineral particles. These metals have the potential to mobilize from soil to groundwater, where they may exceed applicable groundwater RRSs. EPD acknowledges that soil samples analyzed for metals in 2010 and 2014 were either below applicable RRSs or below laboratory reporting limits. Please provide groundwater RRS calculations for manganese and all RCRA metals detected at the site, as well as a contingency plan for the potential RRS exceedance of metals in groundwater. A minimum of one round of pre- and post-injection monitoring is recommended for the applicable metals. In addition, please add specific conductance and pH to the quarterly performance monitoring criteria.*

Response: Analyses for manganese have not been performed for soil or groundwater from the site. However, manganese is likely a naturally occurring metal in the soil beneath the site. The RCRA metal results for the site are listed below.

	Soil (mg/kg)			Groundwater (ug/L)		
Metal	Detects	Average	Maximum	Detects	Average	Maximum
Arsenic	8 / 16	0.63	1.8	0 / 5	--	--
Barium	6 / 6	32.5	45.3	2 / 5	167	274
Cadmium	0 / 16	--	--	0 / 5	--	--
Chromium, total	6 / 6	8.4	12.4	0 / 5	--	--
Chromium, hex	0 / 10	--	--	0 / 7	--	--
Lead	16 / 16	7.6	16.5	0 / 5	--	--
Mercury	0 / 6	--	--	0 / 5	--	--
Selenium	0 / 6	--	--	0 / 5	--	--
Silver	0 / 6	--	--	0 / 5	--	--

Risk Reduction Standards (RRSs) were reported in the Voluntary Remediation Plan. The arsenic groundwater RRS is 10 ug/L and the lead groundwater RRS is 15 ug/L. At EPD's request, additional groundwater RRSs have been calculated, as shown in the amended Table 3-1.

Based on EPD's comment above, it is apparent that EPD is concerned over these metals because the proposed treatment will result in geochemical changes and that could mobilize metals in groundwater. As a result, groundwater analyses are proposed for arsenic, barium, total chromium, lead, and manganese.

Mobilization from a reducing environment is not expected for barium, chromium, and lead. Arsenic and manganese can be mobilized in reducing environments. Manganese can be reduced to the soluble form at a redox potential below approximately 500 mV and the site groundwater is

currently below this redox potential. As a result, manganese is expected to be present in the groundwater from dissolution of naturally occurring manganese in soil. Arsenic mobilization is complicated by the variable mineralized forms that maybe present but it is typically coprecipitated with iron as a hydroxide or oxide. Because the reducing conditions will cause the iron to be reduced and mobilized at a redox potential of approximately 15 mV, arsenic can potentially be mobilized as well. However, the iron, arsenic, and manganese reactions are reversible and the mobilized metals will precipitate back to the mineralized forms once they have migrated beyond the lower redox conditions in the immediate vicinity of the treatment area and encounter dissolved oxygen.

Comment: *MW-7A/B (screened below the water table at the saprolite/sediment interface) is currently the furthest down-gradient monitoring well, but higher TCE concentrations were reported in the groundwater sample from temporary well SB-36 just below water table in the same area. Section 2.3 of the report states that higher TCE concentrations likely exist in the upper sediment unit (Unit A) near MW-7A/B, but there is no permanent monitoring well screened at the water table at the down-gradient extent of the plume. Because access agreements have prevented further plume delineation and surface water sampling, water table TCE concentrations are essential to assess the impact or potential impact from groundwater discharge to the stream down-gradient from the site. In order to demonstrate compliance with the cleanup standards of the VRP, it may become necessary to install an additional monitoring well screened at the water table at the down-gradient extent of the plume in the event that no surface water samples can be collected.*

Response: MW-7 was planned to be installed as a unit A well and it was assumed that the contact between Unit A and the saprolite (Unit B) would become deeper in the direction of the stream and the Bull Creek floodplain. CDM Smith discovered that MW-7A/B was screened primarily in the low permeability saprolite while preparing the hydrogeologic cross section (Figure 2-8 of the Voluntary Remediation Plan). This was disclosed in the plan along with the conclusion that higher VOC concentrations may exist in the higher permeability zone in Unit A. An additional monitor well will be installed at a shallower depth in this area since access has not obtained further downgradient. Access for well installation will have to be obtained from Norfolk Southern Railway Company prior to well installation.

Section 2

Site Investigation and Mitigation (No Changes)

Section 3

Remediation Plan Objectives and Scope (No Changes)

Section 4

Focused Feasibility Study

4.2 Cost Analysis

Key assumptions necessary to support cost development are provided below followed by a cost summary.

- **Anaerobic Biobarrier**
  - 145-foot long biobarrier
  - 20-foot treatment vertical zone
  - 13 injection wells
  - ~~1 sodium lactate injection~~
  - 1 reduced-scale emulsified vegetable oil (EVO) injection
  - 1 bioaugmentation event
  - 3 full-scale emulsified vegetable oil (EVO) injections

Section 5

Remediation Plan Description

5.4 Remedial Construction

The selected biobarrier groundwater remedy will require pre-design, final design, construction, and O&M. These activities are described below

5.4.1 Biobarrier Installation

The planned biobarrier is anticipated to consist of 13 wells installed as shown on Figure 5-1. The actual number of wells will be determined based on results of pre-design activities. The injection wells will be installed using conventional hollow-stem auger techniques. The screens and casings will be 2-inch diameter polyvinyl chloride (PVC). The injection wells will be installed to the depth of bedrock refusal, estimated to be 35 feet, and completed with screens from 15 to 35 feet bls. Final injection well design will be determined in the field based on boring logs and depth to water measurements from existing wells adjacent to the well location.

- Well screens will be supplied in 10-, 5-, and 2.5-foot lengths to allow for variable depths to refusal and water table depths.
- Screen bottoms will be placed 1 foot above the bottom of the borehole.
- Screen tops will be a minimum of 2.5 feet below the estimated water table.
- Bentonite seals will be placed below the water table.

Sand pack will be installed throughout the screen interval to a depth corresponding to 1 to 2 feet above the screen. All wells will have a 2-foot thick bentonite seal emplaced on top of the sand pack. The bentonite seal shall be paced below the water table to ensure it remains hydrated. The boreholes will be grouted to land surface using neat cement.

The wells will be completed with flush-mount, bolt-down protective covers set in concrete pads. The top of the injection well casings will be fitted with PVC 2-inch diameter female NPT pipe threads attached using a solvent weld for future injection purposes. The well plug and casing shall terminate at a level that will allow the bolt-down cover to be removed and reinstalled without interference.

Following a minimum time of 24 hours following grout installation, the injection wells will be developed. Development will consist of pumping approximately 1.5 gallons per linear foot of screen. Development will continue should the development water remain excessively turbid. A groundwater sample will be collected from each injection well following development and analyzed for VOCs.

A short-term injection test will be performed on each injection well. This test will consist of injecting potable water under the pressure of gravity for a period of approximately 30 minutes at a rate not to exceed 5 gpm to determine whether the well can support the design flow rates and pressures. If the flow rate is lower than the design rate, or the injection pressure exceeds the

design pressure, it will need to be determined whether a contingency well(s) is required or whether revised injection volumes may be necessary based on injection performance.

Drums will be used for the collection of soil cuttings and the development water. The soil cuttings and development water will be characterized for disposal purposes and transported to an appropriate offsite disposal facility.

5.4.2 Injection System

The biobarrier injection system will consist of a potable water supply, a portable tank for sodium bicarbonate addition and mixing, an inline chemical feed pump, the electron donor (i.e., ~~sodium lactate and~~ EVO) tank, a well injection manifold, injection distribution hoses, and injection wellheads. The injection system will be constructed to be watertight with solvent welds for PVC fittings and thread sealant on all threaded connections.

Potable water will be supplied via a potable water line with water meter to be installed in the treatment area. Temporary piping and hoses will be used to transfer the potable water from the supply to a portable 21,000-gallon tank. The water in the tank will be mixed with sodium bicarbonate for pH control. Batch process mixing will be completed by recirculating the solution through the tank using a high-volume pump. A submersible pump will be placed into the tank to supply the sodium bicarbonate solution to the electron donor addition system.

The electron donor mixing system will be portable and staged at the center of the biobarrier. The electron donor mixing system will consist of a 275-gallon electron donor reservoir and a chemical feed pump. Pressure gauges will be located upstream and downstream of the chemical feed pump. The chemical feed pump will be set to deliver the electron donor at the predetermined volumetric target donor product percentages.

A pressure reducing valve (PRV) will be located between the chemical feed pump and the injection well manifold. The injection solution will enter the injection well manifold downstream of the PRV. A totalizing flow meter, flow control valve, and pressure gauge will be supplied for each injection well connection on the manifold.

The injection solution will be piped from the injection manifold to the injection wellheads using 5/8-inch diameter hose. During injection, the flow control valve will be used to adjust the individual well injection rates. Injection pressures will be monitored at the manifold and at the wellhead with the flow rates and the PRV adjusted to ensure that the design injection pressures are not exceeded at the injection wellheads.

The injection wellhead assembly will consist of a connection for the delivery hose, a pressure gauge for monitoring injection pressure, and an air vent valve. The vent valve is open as injection is initiated, and once the wellhead assembly is full of solution, the valve is closed. Air in the headspace of the wellhead assembly can stop the flow of fluids into the injection well.

5.4.3 Preliminary Injection Design

The preliminary injection design described in this section is based on CDM Smith's experience with bioremediation and best professional judgement using the currently available data. In addition, the design is focused on preventing the downgradient migration of the injection solution

to prevent discharge to offsite tributary. This design will be adjusted and further detailed based on the pre-design investigation results. However, CDM Smith does not expect the final design to change significantly from this preliminary design. The sequence of events to initiate and maintain treatment within the biobarrier is listed below.

1. Inject a reduced-scale (approximately 25 percent of full scale) volume of EVO ~~immediate-release sodium lactate~~ and sodium bicarbonate bioremediation solution.
2. Establish reducing conditions over 2 months.
3. Inject sodium ascorbate solution and Terra Systems TSI DC® Bioaugmentation Culture.
4. Inject slow-release EVO and sodium bicarbonate bioremediation solution immediately following step 3.
5. Repeat step 4 as needed to maintain treatment.

Product information sheets and safety data sheets for the proposed injection products are provided in **Appendix C**. The bioremediation solution formulations and injection designs are in **Appendix D**. The design for the initial injection in step 1 is intended to prime the groundwater geochemical conditions for bioaugmentation. This injection will utilize ~~an immediately bioavailable electron donor, WilClear Plus® sodium lactate formulation.~~Terra Systems 60% SRS®-FRL Large Droplet EVO ~~-~~and ~~S~~sodium bicarbonate at approximately 5.5% will be injected to buffer pH along with ~~the WilClear Plus® and~~ potable water. The ~~initial~~ reduced-scale injection design is summarized below.

Initial Injection Design

- Total Volume: 1,370 gallons per well, 17,810 gallons total
- 60% SRS®-FRL: 750 gallons total, 4.2 percent by volume
- Sodium Bicarbonate: 8,150 pounds, 5.5 percent by weight

After allowing reducing conditions to be established over a period of approximately two months, the bioaugmentation will be ~~completed~~performed. Prior to bioaugmentation, select injection wells will be tested for pH to determine if the pH is appropriate for bioaugmentation. Sodium ascorbate will be used to prepare the flush solution. This flush solution is necessary to ensure that the water used to flush the bioaugmentation culture into the formation is not toxic to the culture. Terra Systems TSI DC® will be used as the bioaugmentation culture. The bioaugmentation injection design is summarized below.

Bioaugmentation Injection Design

- TSI DC®: 1 liter per well containing over $1E10^{11}$ cells per liter
- Flush Solution: 25 gallons per well, 450 gallons total
- Sodium Ascorbate: 500 grams total

Following bioaugmentation, a full-scale EVO injection will be completed. This first EVO injection will also require use of a sodium ascorbate solution to protect the bioaugmentation culture. This injection will utilize a slow release electron donor, 60% SRS®-FRL ~~LactOil®~~ EVO formulation.

Sodium bicarbonate will be injected to buffer pH along with the 60% SRS®-FRL ~~LactOil®~~ and potable water. The ~~first~~ full-scale EVO injection design is summarized below.

~~First~~ Full-Scale EVO Injection Design

- Total Volume: 5,490 gallons per well, 71,370 gallons total
- 60% SRS®-FRL: 3,000 gallons total, 4.2 percent by volume
- Sodium Bicarbonate: 32,750 pounds, 5.5 percent by weight
- Sodium Ascorbate: 220 pounds total

All injections will be followed by a clean water flush to prevent well fouling. The water flush will consist of approximately 25 gallons of potable water.

CDM Smith estimates that injection pressure should remain below 10 pounds per square inch (psi) to prevent soil rupturing. To be conservative, a limit of 7.5 psi will be used as the maximum well head injection pressure. All injections will be performed under direct supervision of the field staff and monitoring for injectant surfacing near the well heads and along the slope leading down to the railroad tracks will be completed at 30-minute intervals. CDM Smith calculated that minimal pressure will develop at the planned injection flow rate of approximately 3 gpm per well, as shown in Appendix D.

5.4.4 Injection Procedures

The water supply lines, the injection system, and injection wells will be monitored during the all injections for leaks. Appropriate corrective measures will be taken if leaks or injection solution surfacing are discovered. Data collection during the injections will be recorded regularly. The injection data that will be recorded to document the injections includes, but is not limited to, daily volume for the total system, daily volume for each individual well, volume and pressure at each individual well at approximate 2-hour intervals, volume of flush water following injection completion at each individual well, volume of electron donor reservoir at approximate 2-hour intervals, and pressure at the PRV and chemical feed pressure gauges.

5.5 O&M

Maintenance injections using EVO and sodium bicarbonate are expected to be required at approximately 2- —to 5--year intervals. The design for the maintenance injections is summarized below.

O&M EVO Injection Design

- Total Volume: 5,490 gallons per well, 71,370 gallons total
- 60% SRS®-FRL: 3,000 gallons total, 4.2 percent by volume
- Sodium Bicarbonate: 32,750 pounds, 5.5 percent by weight

Biofouling of the injection wells may also occur, and if sufficient injection rates cannot be sustained, maintenance will be required. Biofouling can typically be corrected by redeveloping the wells using surging and pumping. Under extreme circumstances, a bleach product may be required to loosen bacterial growth followed by development.

5.6 Groundwater Monitoring and Reporting

Site-wide groundwater monitoring and reporting will be completed, as currently required under the VRP program. Additional monitoring will be completed to assess the biobarrier performance. This performance monitoring will use groundwater wells MW-3A, -3B, -4A, -4B, -5A/B, and -7A/B. Quarterly sampling will be completed during the first year of the biobarrier operation and semi-annually thereafter. During each sampling event, the following additional data collection and analyses will be completed for these four wells.

In Situ Measurements	Hach Analyses	Laboratory Analyses
Redox potential	Nitrate	Dissolved gases (ethene, ethane, methane)
Dissolved oxygen	Sulfate	Chemical oxygen demand
Turbidity	Ferrous iron	Volatile organic compounds
Specific conductance	Total iron	Arsenic, Barium, Total Chromium, Lead, and Manganese
pH	Carbon dioxide	
Temperature	Alkalinity	

On the first sampling event following bioaugmentation, groundwater samples collected from select injection wells, MW-3A, and MW-3B will be analyzed for DHC bacteria. Additional DHC analyses will be completed on as as-needed basis.

5.8 Schedule

Figure 5-2 includes the updated schedule for the remediation plan at the Cessna GA1 site. Following EPD approval of the remediation plan, approximately seven months will be required to complete the pre-design investigation and design. Remedial construction on the biobarrier and initial injections are anticipated to occur in the ~~first~~ second half of 2018 ~~with~~ followed by bioaugmentation ~~occurring in the second half of 2018~~. Sufficient data to assess the biobarrier effectiveness should be available in early to mid-2019, at which time the CSR report will be prepared. SVE and biobarrier O&M activities will continue on an as-needed basis following submittal of the CSR. CDM Smith intends to establish the SVE system and biobarrier O&M requirements in the environmental covenant, which will provide EPD authority to require continued O&M and approve any termination of O&M activities.

Figures

Task	Start	End	2017												2018												2019											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
EPD Remediation Plan Approval	5/1/17	10/13/17					■	■	■	■	■	■																										
Environmental Covenant	3/1/18	5/30/18															■	■	■																			
Pre-Design Investigation	11/14/17	2/12/18											■	■	■	■																						
Remedial Design	2/12/18	6/12/18														■	■	■	■	■	■																
Remedial Construction																																						
Biobarrier Installation	6/18/18	7/13/18																		■	■																	
Initial Injection	7/16/18	8/10/18																			■	■															
Bioaugmentation	9/24/18	10/19/18																					■	■													
First EVO Injection	9/24/18	10/19/18																					■	■													
Biobarrier O&M	As Needed																																				
SVE O&M	As Needed																																				
Compliance Status Report	7/15/19	10/13/19																															■	■	■	■		
Monitoring/Reporting	Semi-Annual									■	■					■	■					■	■					■	■									

Figure 5-1: Remediation Plan Schedule
Updated September 15, 2017
Cessna GA1 Facility
Columbus, Muscogee County, Georgia

CDM Smith

Tables

Substance	CAS No.	Groundwater RRSs, µg/L			
		Residential (off site)		Non-Residential (on site)	
		Type 1	Type 2*	Type 3	Type 4*
Barium	7440393	200	**3,100**	200	**20,000**
Chromium (total)	7440473	**100**	NC	**100**	NC
Lead	7439921	**15**	NC	**15**	NC
Manganese	7439965	NA	**380**	NA	**2,500**

RRS - Risk Reduction Standard, **BOLD** values are selected for corrective action.

Type 1 - Default based on standard exposure assumptions and defined risk levels for residential properties.

Type 2 - Based on site-specific risk assessment for residential properties.

Type 3 - Default based on standard exposure assumptions and defined risk levels for non-residential properties.

Type 4 - Based on site-specific risk assessment for non-residential properties.

* - Calculated using standard exposure assumptions. Values are rounded to two significant digits to be consistent with the toxicity database.

CAS - Chemical Abstract System

NC - Not calculated.

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Table 3-1

Additional Risk Reduction Standards

Cessna GA1 Facility

Columbus, Muscogee County, Georgia

Appendix C
Bioremediation Product Descriptions

60% SRS®-FRL Large Droplet Emulsified Vegetable Oil (EVO) Substrate for Maximum Retention

United States Patent# RE40,448

The anaerobic bioremediation process uses native or introduced microorganisms (*Dehalococcoides*) to degrade chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to innocuous end products including ethene and ethane. Terra Systems patented **SRS®-FRL** Large Droplet Emulsified Vegetable Oil Substrate includes an anionic emulsifier, which sticks to soil particles and is specifically designed when adherence to the formation is key to making contact with the bacteria. It is particularly useful in high groundwater flow formations such as fractured bedrock formations and is added to the groundwater to rapidly generate reducing conditions and provide the necessary carbon and hydrogen to support biodegradation of the chlorinated solvents.

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

Ingredient	Percent	Description	Benefit
Food Grade U.S. Grown Soybean Oil	60%	Terra Systems operates its own state-of-the-art manufacturing facility.	Long lasting source of carbon and hydrogen, consistent product quality, uniform droplet size, neutral pH, QA/QC lab on floor to check product before shipment.
Food Grade Sodium or Potassium Lactate	4%	Rapidly biodegradable soluble substrate	Rapidly generate anaerobic conditions
Proprietary Food Grade Nutrients	<1%	Proprietary organic and inorganic nutrients such as yeast extract, nitrogen and phosphorus.	Nutrients have been demonstrated to support the growth of the anaerobic microbial population.
Proprietary Food Grade Emulsifiers and Preservatives	7.5%	Proprietary anionic emulsifier	Maximum retention in high groundwater flow-rate aquifers
Vitamin B_{12}	<1%	At least 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
pH	6.5 - 7	6.5 - 7	Optimum microbial activity

Application: Terra Systems **patented**, nutrient enriched, proven slow release SRS®-FRL **large droplet** emulsified vegetable oil substrate with an **anionic emulsifier** is used when a long lasting carbon substrate is desired that provides maximum retention in high groundwater flow-rate aquifers. SRS®-FRL sticks to soil particles and is specifically designed when adherence to the formation is key to making contact with the bacteria.

130 Hickman Road – Suite 1 – Claymont – Delaware – 19703
For More Information Call Michael Free at 302-798-9553 or Email: mfree@terrasystems.net

Customers: SRS®-FRL is used extensively by consultants working with the Air Force, DOD, Navy, and EPA, current and former drycleaners, semiconductor plants and private firms to remediate chlorinated solvent sites and is designed for fractured rock formations, PRBs and high groundwater flow-rate aquifers. SRS®-FRL releases bio-available hydrogen over a period of 3 to 5 years thus enhancing the long-term anaerobic biodegradation of the chlorinated solvents and reducing the frequency of reinjection.

Manufactured vs. Field Emulsion

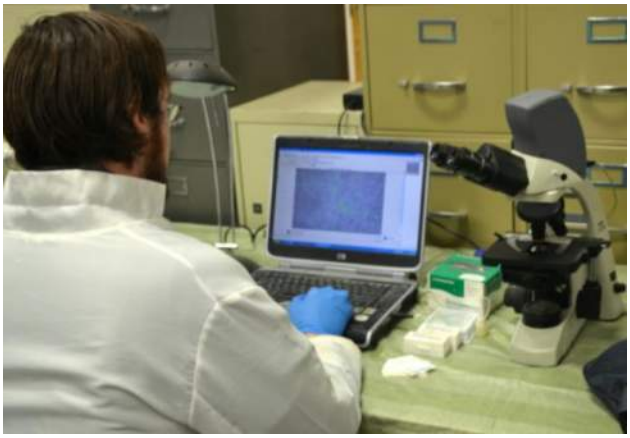
In the early days of in-situ bioremediation when Terra Systems first patented the technology, it was common to bring the water, emulsifiers, oil, and other ingredients to the site and using trash or other pumps to mix the ingredients together to form an emulsion. It soon became apparent that poor emulsion consistency and a broad range of droplet sizes resulted in inadequate and uneven distribution when injected. This resulted in higher long-term costs due to higher reinjection frequency and higher substrate volumes to adequately make contact with the COC.

Don't be "***penny wise and pound foolish***".

Consider:

- ✓ The labor and equipment time and cost of mixing in the field.
- ✓ The need to mix the nutrients and Vitamin B_{12} longer to achieve consistency.
- ✓ The cost of inadequate distribution due to 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 owns and operates a state of the art US based manufacturing plant with an in-house quality control laboratory for strict quality assurance of the emulsion, droplet size and pH.
- SRS®-FRL arrives at the site "***injection ready***" with all the ingredients – Vitamin B_{12}, proprietary nutrients, sodium or potassium lactate and anionic emulsifier(s) already blended together.
- At the PM's request Terra Systems will blend 2-8 g/L of sodium bicarbonate into the SRS®-FRL during manufacturing to counter the acids produced during the fermentation process in the aquifer. This is especially beneficial for marginal pH aquifers of pH 5 – 6.



A Digital Microscope is connected to a laptop computer with proprietary "***Droplet Size Calculation Software***"

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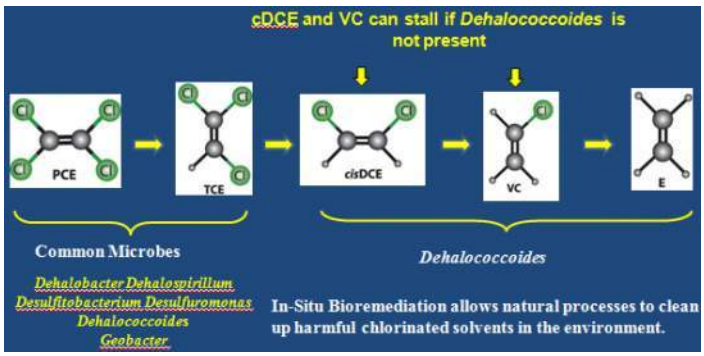
- SRS®-FRL optimizes the naturally occurring biodegradation system by supplying the rate limiting factor (in this case hydrogen) in the degradation of CVOC's, certain pesticides/herbicides, perchlorate, and immobilization of certain metals (Chromium, Arsenic, and some radionucleides).
- The **large droplet size** of **5 μm** combined with the **negative surface charge** on the droplets results in a higher retention in the subsurface.
- Terra Systems holds United States Patent**#RE40,448** for the use of emulsified vegetable oil for remediation of chlorinated solvents.
- The soy bean oil is grown in the United States and provides a **slow release** biodegradable carbon source, which promotes long-term biological activity.
- SRS®-FRL comes **standard** with **biostimulating vitamins** like Vitamin $B_{12,}$ which He et al. 2007 demonstrated is an important micronutrient to enhance dechlorination activity.
- SRS®-FRL contains proprietary organic and inorganic nutrients such as yeast extract, nitrogen and phosphorus, which have been demonstrated to support the growth of the anaerobic microbial population.
- SRS®-FRL comes with **at least 4% sodium** or **potassium lactate** a quick release biodegradable substrate, which helps to "*jump start*" bacterial growth.
- SRS®-FRL emulsified vegetable oil substrate has been validated by the Florida DEP, California Water Board and others.
- SRS®-FRL contains only non-toxic food grade materials, which results in green, sustainable remediation.

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

If the *Dehalococcoides* are not present or are in small numbers Terra Systems **TSI DC®** Bioaugmentation Culture can also be injected.



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For More Information Call Michael Free at 302-798-9553 or Email: mfree@terrasystems.net

60% LARGE DROPLET SLOW RELEASE EMULSIFIED VEGETABLE OIL SUBSTRATE (SRS®-FRL) SAFETY DATA SHEET

1. Product Identification

Synonyms:	60% Large Droplet Slow Release Substrate (SRS®-FRL) Emulsified Vegetable Oil (EVO)
Recommended Use:	Treatment of groundwater contaminated with chlorinated solvents and other anaerobically degradable compounds.
Supplier:	Terra Systems, Inc. 130 Hickman Road, Suite 1 Claymont, Delaware 19703 Telephone (302) 798-9553 Fax (302) 798-9554 www.terrasystems.net

2. Hazards Identification

Emergency Overview	
Caution:	May cause eye irritation.
Health Rating:	1 - Slight
Flammability Rating:	1 - Slight
Reactivity Rating:	1 - Slight
Contact Rating:	1 - Slight
Protective Equipment:	Goggles; Proper Gloves
Storage Color Code:	Green (General Storage)
Potential Health Effects	
Inhalation:	Not expected to be a health hazard. If heated, may produce vapors or mists that irritate the mucous membranes and cause irritation, dizziness, and nausea. Remove to fresh air.
Ingestion:	Not expected to be a health hazard via ingestion. Large doses may produce abdominal spasms, diarrhea.
Skin Contact:	No adverse effects expected. May cause irritation or sensitization in sensitive individuals.
Eye Contact:	May cause mild irritation, possible reddening.
Chronic Exposure:	No information found.
Aggravation of Pre-existing Conditions:	No information found.

3. Composition/Information on Ingredients

Ingredient	Synonyms	CAS #	Percent	Hazardous
Soy bean oil	Soya oil	8001-22-7	60%	No
Emulsifiers, lecithin, and proprietary nutrient package containing nitrogen, phosphorus and vitamin B_{12}		Mixture	5 – 15%	No
Sodium lactate	2-hydroxpropionic acid sodium salt	72-17-3	<5%	Yes
Water		7732-18-5	20 - 30%	No

The emulsifiers, lecithin, and nutrient package mixture is a trade secret and consists of ingredients of unknown acute toxicity.

4. First Aid Measures

Inhalation: Not expected to require first aid measures. Remove to fresh air. Get medical attention for any breathing difficulty.

Ingestion: If large amounts were swallowed, give water to drink and get medical advice.

Skin Contact: Not expected to require first aid measures. Wash exposed area with soap and water. Get medical advice if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

5. Fire Fighting Measures

Fire: Flash point: >200 C (>392 F). Not considered to be a fire hazard. Isolate from heat and open flame.

Explosion: Not considered to be an explosion hazard. Closed containers may explode if exposed to extreme heat.

Fire Extinguishing Media: Dry chemical, foam, or carbon dioxide. Water spray may be ineffective on fire, but can protect fire-fighters and cool closed containers. Use fog nozzles if water is used.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Clean-up personnel may require protective clothing. Absorb in sand, paper towels, “Oil Dry”, or other inert material. Scoop up and containerize for disposal. Flush trace residues to sewer with soap and water. Containerized waste may be sent to an approved waste disposal facility.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Containers of this material are not hazardous when empty since they do vapors or harmful substances; observe all warnings and precautions listed for the product. Do not store above 49 C (120 F). Keep container tightly closed and upright when not in use to prevent leakage.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:	None established.
Ventilation System:	Not expected to require any special ventilation.
Personal Respirators (NIOSH Approved):	Not expected to require personal respirator usage.
Skin Protection:	Wear protective gloves and clean body-covering clothing.
Eye Protection:	Use chemical safety goggles and/or a full face shield where splashing is possible. Provide readily accessible eye wash stations and safety showers.
Slips, Trips, and Falls:	Material is slippery when spilled. Clean up with sand, paper towels, “Oil Dry”, or other inert material.

9. Physical and Chemical Properties

Appearance:	White liquid.
Odor:	Vegetable oil.
Solubility:	Miscible in water.
Specific Gravity (water=1):	0.95-0.98. 8.09 pounds per gallon.
pH:	6-7 (40% aqueous solution)
% Volatiles by volume @ 21C (70F):	Negligible.
Boiling Point:	$\geq$ 100C ($\geq$ 212F)
Melting Point:	No information found.
Flash Point (F):	No information found.
Autoignition Temperature:	No information found.
Decomposition Temperature:	No information found.
Vapor Density (Air=1):	No information found.
Vapor Pressure (mm Hg):	< 1.0 @ 20C (68F).
Evaporation Rate (BuAc=1):	No information found.
Viscosity @23 C (73 F):	213 centipoises (1.2 centipoises diluted 1:10)
Partition Coefficient (octanol/water):	No information found.

10. Stability and Reactivity

Stability:	Stable under ordinary conditions of use and storage.
Reactivity:	Not reactive under ordinary conditions.
Hazardous Decomposition Products:	Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:	Will not occur.
Incompatibilities:	Strong oxidizers, acids.
Conditions to Avoid:	Incompatibles. Isolate from heat and open flame.

11. Toxicological Information

Soybean Oil:	No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH.
Emulsifier/Nutrient Mixture:	No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH.
Sodium Lactate:	Oral rat LD50: 2,000 mg/kg. 100 mg caused mild irritation to rabbit eye in Draize test. This compound is not listed as a carcinogen by IARC, NRP, NIOSH, OSHA, or ACGIM.
SRS-SD:	The toxicity of the mixture has not been measured.

12. Ecological Information

Environmental Fate:	No information found.
Environmental Toxicity:	No information found.
Degradability:	This product is completely biodegradable under both aerobic and anaerobic conditions.
Soil Mobility:	This compound will move with groundwater until the adsorbed onto the soil. Degradation products may be mobile.
Bioaccumulation Potential:	No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

OSHA STATUS: This product is not hazardous under the criteria of the Federal OSHA hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in Section 10.

TSCA STATUS: No component of this product is listed on the TSCA inventory.

CERCLA (Comprehensive Response Compensation, and Liability Act): Not reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act)
Section 312 Extremely Hazardous Substances: None
Section 311/312 Hazard Categories: Non-hazardous Under Section 311/312
Section 313 Toxic Chemicals: None

RCRA STATUS: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste. (40 CFR 261.20-24)

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California safe Drinking Water and Toxic Enforcement Act of 1986. The product contains no chemicals known to the State of California to cause cancer.

16. Other Information

NFPA Ratings:	Health: **1** Flammability: **1** Reactivity: **1**
Date Prepared:	June 19, 2014
Revision Information:	SDS Section(s) changed since last revision of document include: None.
Disclaimer:	Terra Systems, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. TERRA SYSTEMS, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, TERRA

SYSTEMS, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.

Prepared by: Terra Systems, Inc.
Phone Number: (302) 798-9553 (U.S.A.)

Anaerobic Water for Bioaugmentation (DO <0.5 mg/L, <0 mV ORP, Free Chlorine <0.1 mg/L, pH 6-8)

Chemical	Benefits	Drawbacks	Dosage per 1,000 Gallons of Fluid
Sodium Ascorbate or Vitamin C ($NaC_6H_8O_6$)	Non-toxic, food grade Neutral pH Soluble at 620 g/L at 25 C	None	2.5 pounds
Sodium Sulfite (Na_2SO_3)	Soluble at 270 g/L at 20 C	Biocidal Alkaline pH (9.0)	20.9 pounds
Sodium Bisulfite ($NaHSO_3$)	Soluble at 420 g/L at 20 C, removes chlorine	Toxic (preservative) and acidic when dissolved	20.9 pounds
Sodium Thiosulfate Pentrahydrate ($Na_2S_2O_3 \cdot 5H_20$)	Neutral pH Soluble at 701 g/L at 20 C	Biocidal	8.3 pounds
Home Brew of yeast, sugar and site soil	Use soil from local site Inexpensive	Can take several days to a week to drive the water anaerobic	Site specific

SODIUM ASCORBATE
SAFETY DATA SHEET

1. Product Identification

Synonyms: Sodium Salt of Vitamin C
Recommended Use: Additive for treatment of water to remove dissolved oxygen.
CAS#: 134-03-2
Supplier: Terra Systems, Inc.
130 Hickman Road, Suite 1
Claymont, Delaware 19703
Telephone (302) 798-9553
Fax (302) 798-9554
www.terrasystems.net

2. Hazards Identification

Emergency Overview
Caution: May cause eye or skin irritation.
Health Rating: 2 - Moderate
Flammability Rating: 1 - Slight
Reactivity Rating: 0 - None
Contact Rating: 1 - Slight
Protective Equipment: Goggles; Proper Gloves
Storage Color Code: Green (General Storage)
Potential Health Effects
Inhalation: Not expected to be a health hazard.
Ingestion: Hazard via ingestion.
Skin Contact: May cause irritation or sensitization in sensitive individuals.
Eye Contact: May cause mild irritation.
Chronic Exposure: No information found.
Aggravation of Pre-existing Conditions: No information found.

3. Composition/Information on Ingredients

Ingredient	Synonyms	CAS #	Percent	Hazardous
Sodium Ascorbate	Sodium Salt of Vitamin C	134-03-2	100	No

4. First Aid Measures

Inhalation: Not expected to require first aid measures. Remove to fresh air. Get medical attention for any breathing difficulty.

Ingestion: If large amounts were swallowed, give water to drink and get medical advice.

Skin Contact: Not expected to require first aid measures. Wash exposed area with soap and water. Get medical advice if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

5. Fire Fighting Measures

Fire: Flash point and auto ignition: not available. May be combustible at high temperature. Isolate from heat and open flame.

Explosion: Slightly explosive in presence of open flames and sparks. Non-flammable in presence of shocks.

Fire Extinguishing Media: Dry chemical powder for small fires. Water spray, fog, or foam may be effective for large fires. Do not use water jet. .

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode. Fine dust dispersed in air at sufficient concentrations with an ignition source is a potential dust explosion hazard.

6. Accidental Release Measures

Clean-up personnel may require protective clothing. Scoop up and containerize for disposal. Flush trace residues to sewer with soap and water. Containerized waste may be sent to an approved waste disposal facility.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area away from sources of heat or ignition. Protect against physical damage. Containers of this material may pose a fire risk due to dusts. Keep container tightly closed and upright when not in use to prevent leakage. Sensitive to light. Store in light-resistant containers.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits: None established.

Ventilation System: Use ventilation to keep exposure below exposure limits.

Personal Respirators (NIOSH

Approved):	Use dust respirator usage.
Skin Protection:	Wear protective gloves and clean body-covering clothing.
Eye Protection:	Use chemical safety goggles and/or a full face shield where splashing is possible. Provide readily accessible eye wash stations and safety showers.

9. Physical and Chemical Properties

Appearance:	White to yellowish granular or crystalline solid
Molecular Weight:	198.11 g/mole
Odor:	Odorless.
Solubility:	620 g/L solubility in water at 25 C.
Specific Gravity (water=1):	1.66 (water = 1).
pH:	Not available
% Volatiles by volume @ 21C (70F):	Negligible.
Boiling Point:	No information found.
Melting Point:	No information found.
Flash Point (F):	No information found.
Autoignition Temperature:	No information found.
Decomposition Temperature:	Decomposition temperature 200 C (392 F)
Vapor Density (Air=1):	No information found.
Vapor Pressure (mm Hg):	Not applicable.
Evaporation Rate (BuAc=1):	Not applicable.
Partition Coefficient (octanol/water):	No information found.

10. Stability and Reactivity

Stability:	Stable under ordinary conditions of use and storage.
Reactivity:	Not reactive under ordinary conditions.
Hazardous Decomposition Products:	Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:	Will not occur.
Incompatibilities:	Strong oxidizers, reducing agents, acids, alkalis.
Conditions to Avoid:	Incompatibles. Isolate from heat and open flame.

11. Toxicological Information

Routes of Entry	Inhalation and ingestion.
Toxicity to Animals:	Acute oral toxicity (LD50): 16300 mg/kg Rat.
Chronic Effects on Humans:	Carcinogenic effects – classified 4 (no evidence) by NTP and none by OSHA. Mutagenic effects – mutagenic to mammalian somatic cells. May cause damage to kidneys, gastrointestinal tract, and upper respiratory tract. May affect genetic material (mutagenic) based on animal test data. No human data found

(Registry of Toxic Effects of Chemicals). May cause cancer based on animal test data. No human data found (Registry of Toxic Effects of Chemicals).

Other Toxic Effects: Hazardous in case of ingestion. Slightly hazardous in case of skin contact (irritant) or inhalation.

12. Ecological Information

Environmental Fate: No information found.
Environmental Toxicity: No information found.
Degradability: This product is inherently biodegradable under both aerobic and anaerobic conditions.
Soil Mobility: No information found.
Bioaccumulation Potential: Does not bioaccumulate.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

OSHA STATUS: This product is not hazardous under the criteria of the Federal OSHA hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in Section 10.

TSCA STATUS: No component of this product is listed on the TSCA inventory.

CERCLA (Comprehensive Response Compensation, and Liability Act): Not reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act)
Section 312 Extremely Hazardous Substances: None
Section 311/312 Hazard Categories: Non-hazardous Under Section 311/312
Section 313 Toxic Chemicals: None

RCRA STATUS: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste. (40 CFR 261.20-24)

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California safe Drinking Water and Toxic Enforcement Act of 1986. The product contains no chemicals known to the State of California to cause cancer.

16. Other Information

NFPA Ratings:	Health: **2** Flammability: **1** Reactivity: **0**
Date Prepared:	February 3, 2015
Revision Information:	SDS Section(s) changed since last revision of document include: None.
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Prepared by:	Terra Systems, Inc.
Phone Number:	(302) 798-9553 (U.S.A.)

LINK TO:
TSI-DC
Safety Data Sheet

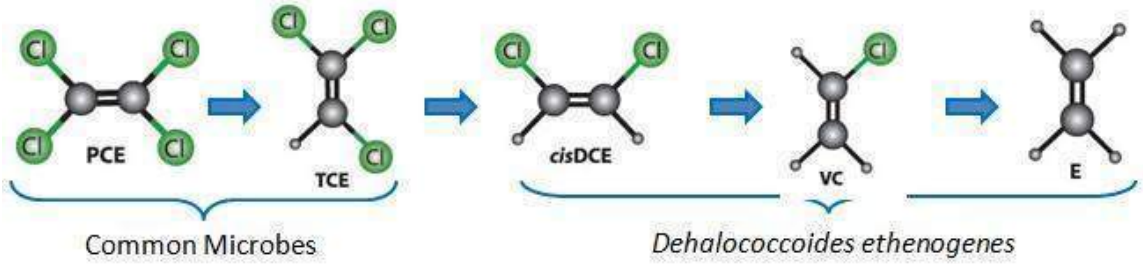
TSI DC *Dehalococcoides mccartyii* Bioaugmentation Culture®

>1 x 10^{11} Dehalococcoides cells/L

TSI DC *Dehalococcoides mccartyii* Bioaugmentation Culture® is an enriched natural bacteria culture that contains *Dehalococcoides* species for bioaugmentation. This culture dechlorinates tetrachloroethene (PCE) and trichloroethene (TCE) to the non-toxic product ethene. The culture also biodegrades 1,1,1-trichloroethane to 1,1-dichloroethene, 1,1-dichloroethane, and chloroethane. It also can biodegrade carbon tetrachloride and chloroform to methylene chloride and innocuous products. It can be used at sites where bacteria capable of complete reductive dechlorination are not present or there is a need to decrease the remediation time frame. It is estimated that *Dehalococcoides* are not present in 10 to 40 percent of chlorinated solvent contaminated sites.

Key Benefits of TSI DC *Dehalococcoides mccartyii* Bioaugmentation Culture®

The TSI-DC® Bioaugmentation Culture has been proven to be effective with a growing body of laboratory and field data demonstrating that the *Dehalococcoides* group of microorganisms is solely responsible for the complete dechlorination of PCE and TCE to ethene. At sites where *Dehalococcoides* microorganisms are not present or are found at low numbers, the process will often "**stall**" at cis-1,2-dichloroethene. The TSI-DC® Bioaugmentation Culture will promote the complete dechlorination of PCE or TCE. The TSI-DC® Bioaugmentation Culture contains greater than **1 x 10^{11}** *Dehalococcoides*/L.



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On the Web: www.terrasystems.net

The TSI-DC® Bioaugmentation Culture is cost effective and is typically a minor component of the total remediation project cost. At sites where the *Dehalococcoides* is present, but at low numbers or poorly distributed, bioaugmentation can be used to reduce the treatment time. Bioaugmentation can also reduce the time required to grow the *Dehalococcoides* population to effective cell densities. Therefore, future costs can be reduced.

- The TSI-DC® Bioaugmentation Culture is competitively priced at less than $150 per liter of culture plus shipping depending on volume ordered.
- The TSI-DC® Bioaugmentation Culture works with all commonly used electron donors.
- The TSI-DC® Bioaugmentation Culture is not genetically modified or engineered.
- The TSI-DC® Bioaugmentation Culture is certified to be free of known human pathogens.
- The TSI-DC® Bioaugmentation Culture has rigorous quality control procedures in place to ensure that each shipment is of the highest quality, stable, safe, effective and free of chlorinated volatile organic compounds.
- The TSI-DC® Bioaugmentation Culture is shipped overnight in specially designed stainless steel containers that prevent exposure to air and are safe & easy to handle.

Each purchase comes with free technical phone support from an experienced Terra Systems microbiologist. A senior level microbiologist is also available to be on-site to support the successful application at $1,200 per day.

130 Hickman Road, Suite 1
Claymont, Delaware 19703
Phone: 302-798-9553 • Email: mfree@terrasystems.net
On the Web: www.terrasystems.net

LINK TO:
TSI-DC
Product Sheet

TERRA SYSTEMS, INC DECHLORINATING BIOAUGMENTATION CULTURE (TSI-DC) SAFETY DATA SHEET

1. Product Identification

Synonyms: *Dehalococcoides* or DHC Microbial Consortium (TSI-DC)

Recommended Use: Bioremediation of groundwater contaminated with chlorinated solvents such as tetrachloroethene and trichloroethene.

Supplier:
Terra Systems, Inc.
130 Hickman Road, Suite 1
Claymont, Delaware 19703
Telephone (302) 798-9553
Fax (302) 798-9554
www.terrasystems.net

2. Hazards Identification

The available data indicates no known hazards associated with exposure to this product. Nevertheless, individuals who are allergic to enzymes or other related proteins should avoid exposure and handling. Health effects associated with exposure to similar organisms are listed below.

Emergency Overview

Caution: May cause eye irritation or discomfort if ingested or inhaled or allergic reaction to sensitive individuals.

Health Rating: 1 - Slight

Flammability Rating: 0 - None

Reactivity Rating: 0 - None

Contact Rating: 1 - Slight

Protective Equipment: Goggles; Proper Gloves

Storage Color Code: Green (General Storage)

Potential Health Effects

Inhalation: Not expected to be a health hazard. Hypersensitive individuals may experience breathing difficulties after inhalation of aerosols.

Ingestion: Not expected to be a health hazard via ingestion. Ingestion of large quantities may result in abdominal discomfort including nausea, vomiting, cramps, diarrhea, and fever.

Skin Contact: No adverse effects expected. May cause irritation or sensitization in sensitive individuals upon prolonged contact.

Eye Contact: May cause mild irritation, possible reddening unless immediately rinsed.

Chronic Exposure: No information found.

Aggravation of Pre-existing Conditions: No information found.

3. Composition/Information on Ingredients

Ingredient	Synonyms	CAS #	Percent	Hazardous
Non-hazardous ingredients	DHC	Not applicable	100%	No

4. First Aid Measures

Inhalation: Not expected to require first aid measures. Remove to fresh air. Get medical attention for any breathing difficulty or if allergic symptoms develop.

Ingestion: Thoroughly rinse mouth with water. Do not induce vomiting unless directed to do so by medical personnel. Get immediate medical attention. Never give anything by mouth to an unconscious or convulsing person.

Skin Contact: Not expected to require first aid measures. Wash exposed area with soap and water. Get medical advice if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

Note to Physicians: All treatments should be based on observed signs and symptoms of distress in the patient. Consideration should be given to the possibility that overexposure to materials other than this material may have occurred.

5. Fire Fighting Measures

Fire: Non-flammable. Flash point and flammable limits are not available.

Explosion: Not considered to be an explosion hazard.

Fire Extinguishing Media: Dry chemical, foam, carbon dioxide, or water.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Clean-up personnel may require protective clothing and avoid skin contact. Absorb in sand, paper towels, or other inert material. Scoop up and containerize for disposal. Flush trace residues to sewer with soap and water. Containerized waste may be sent to an approved waste disposal facility. After clean-up, disinfect all cleaning materials and storage containers that come in contact with the spilled liquid.

7. Handling and Storage

Avoid breathing breathe aerosol. Avoid contact with skin. Use personal protective equipment recommended in Section 8. Keep containers tightly closed in a cool, well-ventilated area. The DHC microbial consortium (TSI-DC) can be supplied in stainless steel kegs designed for maximum working pressure of 130 psi and equipped with pressure relief valves. The kegs are pressurized with nitrogen gas up to the pressure of 15 psi. Do not exceed pressure of 15 psi during transfer of DHC microbial consortium (TSI-DC) from kegs. Don't open keg if content of the keg is under pressure. DHC microbial consortium (TSI-DC) may be stored for up to 3 weeks at temperature 2-4°C without aeration. Avoid freezing.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:	None established.
Ventilation System:	Not expected to require any special ventilation. Provide adequate ventilation to remove odors.
Personal Respirators (NIOSH Approved):	Not expected to require personal respirator usage. If aerosols might be generated, use N95 respirator.
Skin Protection:	Wear protective rubber, nitrile, or vinyl gloves and clean body-covering clothing.
Eye Protection:	Use chemical safety goggles and/or a full face shield where splashing is possible. Provide readily accessible eye wash stations and safety showers.

9. Physical and Chemical Properties

Appearance:	Light greenish, murky liquid.
Odor:	Musty.
Solubility:	Soluble in water.
Specific Gravity (water=1):	1.0. 8.34 pounds per gallon.
pH:	6-8
% Volatiles by volume @ 21C (70F):	Negligible.
Boiling Point:	100C (212F)
Melting Point:	0C (32F)
Flash Point (F):	No information found.
Autoignition Temperature:	No information found.
Decomposition Temperature:	No information found.
Vapor Density (Air=1):	No information found.
Vapor Pressure (mm Hg):	24 mm @ 25C (77F).
Evaporation Rate (BuAc=1):	No information found.
Viscosity @23 C (73 F):	1 centipoises

Partition Coefficient (octanol/water): No information found.

10. Stability and Reactivity

Stability: Stable under ordinary conditions of use and storage.
Reactivity: Not reactive under ordinary conditions.
Hazardous Decomposition Products: None.
Hazardous Polymerization: Will not occur.
Incompatibilities: Strong oxidizers, acids, water reactive materials.
Conditions to Avoid: Incompatibles. Isolate from heat and open flame.

11. Toxicological Information

TSI-DC No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH. It has tested negative for pathogenic microorganisms such as *Bacillus cereus, Listeria monocytogens, Salmonella* sp., *Pseudomonas* sp., fecal coliform, total coliform, yeast, and mold.

12. Ecological Information

Environmental Fate: No information found.
Environmental Toxicity: No information found.
Degradability: This product is completely biodegradable under both aerobic and anaerobic conditions.
Soil Mobility: This compound will move with groundwater until the adsorbed onto the soil.
Bioaccumulation Potential: No information found.

13. Disposal Considerations

Waste Disposal Method: No special disposal methods are required. The material is compatible with all known biological treatment methods. To reduce odors and permanently inactivate microorganisms, mix 100 parts (by volume) of TSI-DC consortium with 1 part (by volume) of bleach. Dispose of in accordance with local, state and federal regulations.

14. Transport Information

DOT Classification: N/A
Labeling: NA
Shipping Name: Not regulated

15. Regulatory Information

OSHA STATUS: This product is not hazardous under the criteria of the Federal OSHA hazard Communication Standard 29 CFR 1910.1200.

TSCA STATUS: No component of this product is listed on the TSCA inventory.
CERCLA (Comprehensive Response Compensation, and Liability Act): Not reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act)
Section 312 Extremely Hazardous Substances: None
Section 311/312 Hazard Categories: Non-hazardous Under Section 311/312
Section 313 Toxic Chemicals: None

RCRA STATUS: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste. (40 CFR 261.20-24)

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California safe Drinking Water and Toxic Enforcement Act of 1986. The product contains no chemicals known to the State of California to cause cancer.

16. Other Information

NFPA Ratings:	Health: **1** Flammability: **0** Reactivity: **0**
Date Prepared:	March 26, 2014
Revision Information:	SDS Section(s) changed since last revision of document include: None.
Disclaimer:	Terra Systems, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. TERRA SYSTEMS, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, TERRA SYSTEMS, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.
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Brenntag Canada Inc.

BRENNTAG

MATERIAL SAFETY DATA SHEET

SODIUM BICARBONATE, SOLID

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Brenntag Canada Inc.
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Toronto, ON
M8Z 2G6
(416) 259-8231

Website: http://www.brenntag.ca

WHMIS#: 00060700
Index: GCD0050/14A
Effective Date: 2014 March 31
Date of Revision: 2014 March 31

EMERGENCY TELEPHONE NUMBER (For Emergencies Involving Chemical Spills or Releases)

1 855 273 6824

PRODUCT IDENTIFICATION

Product Name:	Sodium Bicarbonate, Solid.
Chemical Name:	Carbonic Acid, Monosodium Salt.
Synonyms:	Baking Soda; Bicarbonate of Soda; Sodium Acid Carbonate; Sodium Hydrogen Carbonate; Monosodium Carbonate; Sodium Bicarbonate Tech; Sodium Bicarbonate USP No. 1, No. 4, No. 5; Sodium Bicarbonate Industrial; Sodium Bicarbonate Industrial NSF; Sodium Bicarbonate FG..
Chemical Family:	Sodium salts.
Molecular Formula:	NaCHO3.
Product Use:	Fire extinguishing agent. Pharmaceutical. Baking powder. Chemical intermediate. Food additive.

WHMIS Classification / Symbol:

Not WHMIS Regulated.

READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Ingredient	*CAS#*	*ACGIH TLV (TWA)*	*% Concentration*
Sodium Bicarbonate	144-55-8	---	95 - 100

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:	Low hazard for usual industrial or commercial handling. Dust may cause mechanical irritation to skin, eyes and respiratory tract. See "Other Health Effects" Section. Can decompose at high temperatures forming toxic gases.

POTENTIAL HEALTH EFFECTS

Inhalation:	Product may be mildly irritating to the nose, throat and respiratory tract and may cause coughing and sneezing. Excessive contact with powder may cause drying of mucous membranes of nose and throat due to absorption of moisture and oils. See "Other Health Effects" Section.
Skin Contact:	This product may cause irritation due to abrasive action. Excessive contact with powder may cause drying of the skin due to absorption of moisture and oils.
Skin Absorption:	Not likely to be absorbed through the skin.

Eye Contact:	This product may cause irritation, redness and possible damage due to abrasiveness. Excessive contact with powder may cause drying of mucous membranes of the eyes due to absorption of moisture and oils.
Ingestion:	Ingestion is not a likely route of exposure. This product may cause mild gastrointestinal discomfort.
Other Health Effects:	Low hazard for usual industrial or commercial handling. May cause central nervous system (CNS) depression, metabolic alkalosis, hypernatremia and pneumoconiosis. CNS depression is characterized by headache, dizziness, drowsiness, nausea, vomiting and incoordination. Severe overexposures may lead to coma and possible death due to respiratory failure. Pneumoconiosis is the deposition of dust in the lungs and the tissue's reaction to its presence. When exposure to the dust is severe or prolonged, the lungs' defenses are overwhelmed. In general, long-term exposure to high concentrations of dust may cause increased mucous flow in the nose and respiratory system airways. This condition usually disappears after exposure stops. Controversy exists as to the role exposure to dust has in the development of chronic bronchitis (inflammation of the air passages into the lungs). Other factors such as smoking and general air pollution are more important, but dust exposure may contribute. Sodium salts have a hypothetical risk of hypernatremia. Hypernatraemia is a term that describes an abnormally high plasma concentration of sodium ions. This condition may lead to weakness, restlessness, dizziness, headache, convulsions and coma. (6) Metabolic alkalosis is a condition wherein the concentration of the arterial plasma bicarbonate concentration increases.

4. FIRST AID MEASURES

FIRST AID PROCEDURES

Inhalation:	If respiratory problems arise, move the victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical advice IMMEDIATELY.
Skin Contact:	Start flushing while removing contaminated clothing. Wash affected areas thoroughly with soap and water. If irritation, redness, or a burning sensation develops and persists, obtain medical advice.
Eye Contact:	Immediately flush eyes thoroughly for 5 minutes with running water. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention. Do not allow victim to rub eyes. Do not attempt to manually remove anything stuck to the eye(s). (4)
Ingestion:	Do not attempt to give anything by mouth to an unconscious person. If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. DO NOT induce vomiting. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. Obtain medical attention IMMEDIATELY.
Note to Physicians:	Treat symptomatically. Sodium salts have a hypothetical risk of hypernatremia. In addition to calcium levels, sodium and phosphate levels should be monitored. Medical conditions that may be aggravated by exposure to this product include diseases of the skin, eyes or respiratory tract.

5. FIRE-FIGHTING MEASURES

Flashpoint (°C)	***AutoIgnition Temperature (°C)***	**Flammability Limits in Air (%):** ***LEL***	***UEL***
Not Flammable. (3)	Not available.	Not available.	Not available.

Flammability Class (WHMIS):	Not regulated.
Hazardous Combustion Products:	Thermal decomposition products are toxic and may include soda ash (sodium carbonate), oxides of sodium, carbon and irritating gases. Sodium bicarbonate begins to decompose at 50°C, releasing carbon dioxide, sodium carbonate and water. Total decomposition occurs at 270°C. (4)
Unusual Fire or Explosion Hazards:	Avoid accumulation and dispersion of dust. Spilled material may cause floors and contact surfaces to become slippery. Do not flush with water as aqueous solutions or powders that become wet render surfaces extremely slippery. Enforce NO SMOKING rules.
Sensitivity to Mechanical Impact:	Not expected to be sensitive to mechanical impact.
Rate of Burning:	Not available.

Explosive Power:	Not available.
Sensitivity to Static Discharge:	Not expected to be sensitive to static discharge.

EXTINGUISHING MEDIA

Fire Extinguishing Media:	Is used as an extinguishing agent for all classes of fires. Use media appropriate for surrounding fire and/or materials.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters:	Isolate materials that are not involved in the fire and protect personnel. Do not flush with water as aqueous solutions or powders that become wet render surfaces extremely slippery. Spilled material may cause floors and contact surfaces to become slippery.
Fire Fighting Protective Equipment:	Use self-contained breathing apparatus and protective clothing.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures:	In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS. Minimize air borne spreading of dust. Wear respirator, protective clothing and gloves. Avoid dry sweeping. Do not use compressed air to clean surfaces. Vacuuming or wet sweeping is preferred. Return all material possible to container for proper disposal. Do not allow to enter sewers or watercourses. Any recovered product can be used for the usual purpose, depending on the extent and kind of contamination. Where a package (drum or bag) is damaged and / or leaking, repair it, or place it into an over-pack drum immediately so as to avoid or minimize material loss and contamination of surrounding environment. Replace damaged containers immediately to avoid loss of material and contamination of surrounding atmosphere. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

7. HANDLING AND STORAGE

HANDLING

Handling Practices:	Use normal "good" industrial hygiene and housekeeping practices. Avoid accumulation and dispersion of dust. Clean up immediately to eliminate slipping hazard.
Ventilation Requirements:	See Section 8, "Engineering Controls".
Other Precautions:	Use only with adequate ventilation and avoid breathing dusts. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

STORAGE

Storage Temperature (°C):	See below.
Ventilation Requirements:	General exhaust is acceptable.
Storage Requirements:	Store in a cool, dry and well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Avoid moisture contamination. Prolonged storage may result in lumping or caking. Protect from direct sunlight. Protect against physical damage.
Special Materials to be Used for Packaging or Containers:	Materials of construction for storing the product include: Multi-layer bags or sacks. Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment, which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls:	General exhaust is acceptable. Local exhaust ventilation preferred. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Ventilate low lying areas such as sumps or pits where dense dust may collect.

PERSONAL PROTECTIVE EQUIPMENT (PPE)	
Eye Protection:	Safety glasses with side shields are recommended to prevent eye contact. Use chemical safety goggles when there is potential for eye contact. Contact lenses should not be worn when working with this material.
Skin Protection:	Gloves and protective clothing made from cotton, leather, rubber or plastic should be impervious under conditions of use. Prior to use, user should confirm impermeability. Discard contaminated gloves.
Respiratory Protection:	No specific guidelines available. A NIOSH/MSHA approved dust mask for concentrations of nuisance dust up to 100 mg/m³ particulate. An air-supplied respirator if concentrations are higher or unknown.
Other Personal Protective Equipment:	Wear regular work clothing. The use of coveralls is recommended. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

EXPOSURE GUIDELINES

Particulate Not Otherwise Classified:

ACGIH	OSHA
10 mg/m³ - Inhalable particulate	50 mppcf* or 15 mg/m³ - Total Dust
3 mg/m³ - Respirable particulate	15 mppcf* or 5 mg/m³ - Respirable Fraction

* mppcf = million particles per cubic foot

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State:	Solid.
Appearance:	White granular solid.
Odour:	Odourless.
Odour Threshold (ppm):	Not applicable.
Boiling Range (°C):	Not available.
Melting/Freezing Point (°C):	Not applicable.
Vapour Pressure (mm Hg at 20° C):	Not available.
Vapour Density (Air = 1.0):	Not applicable.
Relative Density (g/cc):	2.22. (3)
Bulk Density:	500 - 1 200 kg/m³. (3)
Viscosity:	Not applicable.
Evaporation Rate (Butyl Acetate = 1.0):	Not applicable.
Solubility:	Soluble in water. Hygroscopic (readily absorbs water).
% Volatile by Volume:	Not available.
pH:	8.3 - 8.6 (1 % solution). (3)
Coefficient of Water/Oil Distribution:	Not available.
Volatile Organic Compounds (VOC):	Not applicable.
Flashpoint (°C):	Not Flammable. (3)

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY	
Under Normal Conditions:	Stable.
Under Fire Conditions:	Not flammable.
Hazardous Polymerization:	Will not occur.
Conditions to Avoid:	High temperatures, sparks, open flames and all other sources of ignition. Minimize air borne spreading of dust. Avoid direct sunlight. Avoid moisture contamination. Hygroscopic.
Materials to Avoid:	Strong oxidizers. Lewis or mineral acids. Vigourous effervescence results on mixture with acids. Potassium-Sodium alloys. Monoammonium Phosphate. 2-Furaldehyde. (4)
Decomposition or Combustion Products:	Thermal decomposition products are toxic and may include soda ash (sodium carbonate), oxides of sodium, carbon and irritating gases. Sodium bicarbonate begins to decompose at 50°C, releasing carbon dioxide, sodium carbonate and water. Total decomposition occurs at 270°C. (4)

11. TOXICOLOGICAL INFORMATION

TOXICOLOGICAL DATA:

SUBSTANCE	*LD50 (Oral, Rat)*	*LD50 (Dermal, Rabbit)*	*LC50 (Inhalation, Rat, 4h)*
Sodium Bicarbonate	4 220 mg/kg (1)	---	---

Carcinogenicity Data:	The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.
Reproductive Data:	No adverse reproductive effects are anticipated.
Mutagenicity Data:	No adverse mutagenic effects are anticipated.
Teratogenicity Data:	No adverse teratogenic effects are anticipated.
Respiratory / Skin Sensitization Data:	None known.
Synergistic Materials:	None known.
Other Studies Relevant to Material:	Application of 0.2 g of 100 % Sodium Bicarbonate caused moderate eye irritation lasting at least 7 days. In another study, application of 0.86 g caused slight redness. Application to the skin of 0.3 g for 4 hours caused very slight irritation in 1/3 animals tested (graded 0.11 out of 8). (4) An increase in bladder cancer was observed in rats fed a known carcinogen for 4 weeks, then 3 % Sodium Bicarbonate in the diet for 32 weeks, compared to animals receiving only the know carcinogen. An increase in bladder cancer was also observed in rats fed 0.64 % Sodium Bicarbonate and 1.25 % of another known carcinogen for 104 weeks (compared to the non-exposed animals). An increase in DNA synthesis and morphological alterations in the bladder epithelium was observed after feeding rats 3 % Sodium Bicarbonate in their diets for 8 weeks. These studies were conducted to investigate the mechanism by which carbonate salts promote bladder cancer in animals exposed to known carcinogen. (4) No adverse effects were observed after feeding up to 580 mg/Kg to mice, up to 340 mg/Kg to rats and up to 330 mg/Kg to rabbits. Screening tests using both yeast and bacterial cultures were negative with and without metabolic activation. (4)

12. ECOLOGICAL INFORMATION

Ecotoxicity:	May be harmful to aquatic life. Sodium Bicarbonate: 96-hour LC50 (Lepomis macrochirus) = 7 100 mg/l. (3) 48-hour LC50 (Culex sp. Larvae or mosquito) = 2 000 mg/l. (3)
Environmental Fate:	Product has an unaesthetic appearance and can be a nuisance. Can be dangerous if allowed to enter drinking water intakes. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals:	None required.
Waste Disposal Methods:	This information applies to the material as manufactured. Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.
Safe Handling of Residues:	Empty containers retain product residue. No special treatment required.
Disposal of Packaging:	Recycling is encouraged. Treat package in the same manner as the product. Empty package may be disposed of with normal garbage.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT SHIPPING DESCRIPTION:

This product is not regulated by TDG.

Label(s): Not applicable. Placard: Not applicable.

ERAP Index: -----. Exemptions: None known.

US DOT CLASSIFICATION (49CFR 172.101, 172.102):

This product is not regulated by DOT.

Label(s): Not applicable. Placard: Not applicable.

CERCLA-RQ: Not available. Exemptions: Not available.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR:	This material is included on the DSL under the CEPA.
CEPA - NPRI:	Not included.
CANADIAN FOOD AND DRUG ACT/REGULATIONS:	The use of this material/product as a food additive is regulated by Health Canada in the Food and Drug Act and the Food and Drug Regulations. It is incumbent on the user of this material/product to ensure any intended food application is consistent with Health Canada guidelines. Food Grade designation in no way implies that the product is safe for consumption by humans.

Controlled Products Regulations Classification (WHMIS):

Not WHMIS Regulated.

USA

Environmental Protection Act:	This material is included on the TSCA Inventory.
OSHA HCS (29CFR 1910.1200):	Not regulated.
U.S. FOOD AND DRUG ADMINISTRATION:	This material/product is regulated for use by the US FDA. It is incumbent on the user of this material/product to ensure any intended food application is consistent with US FDA guidelines. Food Grade designation in no way implies that the product is safe for consumption by humans.

NFPA: 0 Health, 0 Fire, 0 Reactivity (3)

HMIS: 0 Health, 0 Fire, 0 Reactivity (3)

INTERNATIONAL

Sodium Bicarbonate is found on the following inventories: EINECS (European Inventory of Existing Commercial Chemical Substances).

16. OTHER INFORMATION

REFERENCES

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
3. Supplier's Material Safety Data Sheet(s).
4. CHEMINFO chemical profile, Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
5. Guide to Occupational Exposure Values, 2011, American Conference of Governmental Industrial Hygienists, Cincinnati, 2011.
6. Regulatory Affairs Group, Brenntag Canada Inc.
7. The British Columbia Drug and Poison Information Centre, Poison Managements Manual, Canadian Pharmaceutical Association, Ottawa, 1981.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

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Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

Appendix D
Bioremediation Injection Design

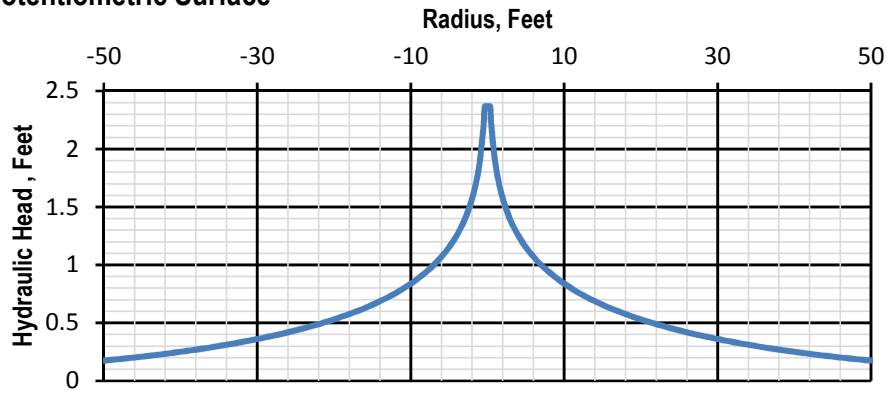
Electron Donor Quantity Estimates

Treatment Zone Characteristics		
8,130	Ft^2	Treatment Zone Area
15	Ft	Top of Treatment Zone
35	Ft	Bottom of Treatment Zone
20	Ft	Treatment Zone Thickness
15%	%	Treatment Zone Effective Porosity
30%	%	Treatment Zone Total Porosity
1.5	Tons / Yd^3	Treatment Zone Density
9,033	Tons	Formation Mass
182,450	Gal	Treatment Zone Water Volume
1,522,618	Lbs.	Treatment Zone Water Mass
Electron Donor Requirements		
10,000	Mg / L	Target Active Electron Donor Concentration
1.00%	%	
15,226	Lbs.	Target Active Electron Donor Mass
8.09	Lbs. / Gal	EVO Density
64%	%	Percent Active Electron Donor in Product
23,791	Lbs.	EVO Mass Requirements
2,941	Gal	EVO Volume Requirements
Electron Donor Solution Formulation		
4.00%	%	Target Donor Product Concentration (mass)
594,773	Lbs.	Mass of Total Solution
71,360	Gal	Volume of Total Solution
68,419	Gal	Total Water Addition for Injection Solution
4.1%	%	Target Donor Product in Solution (volume)
Injection Well Delivery Calculations		
13	Each	Number of Injection Points
5,489	Gal	Solution Injected Per Point
3	Gal / Min	Injection Flow Rate Per Point
30	Hrs.	Injection Duration Per Point
7	Points	Well Set Manifold Size
1.9	Sets	Well Set Quantity
57	Hrs.	Total Injection Event Duration

Injection Performance Simulation

Injection Performance Parameters		
4.25	In	Injection Well Sand Pack Radius
13	Ft	Depth to Top of Sand Pack
15	Ft	Depth to Groundwater
8.5	PSI	Maximum Injection Pressure (15% contingency)
0.0	PSI	Simulated Maximum Injection Pressure
15	Ft	Delivery Radius Under Injection
1	D	Time Required for Full Delivery
0.0	Mo	
Aquifer Characteristics		
1,500	GPD / Ft^2	Transmissivity
10.0	Ft / D	Hydraulic Conductivity
15	Ft	Target Injection Radius
0.012	Ft/Ft	Ambient Hydraulic Gradient
0.80	Ft/D	Ambient Groundwater Velocity
20.0	Ft	Aquifer Thickness

Potentiometric Surface



Biobarrier Full-Scale Injection Worksheet
60% SRS®-FRL Large Droplet EVO Injection Design

CDM Smith

Cessna GA1 Facility
Columbus, Muscogee County, Georgia

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