

11 November 2014

Ms. Melanie Morash  
Remedial Project Manager  
U. S. Environmental Protection Agency  
Region 9  
75 Hawthorne Street, SFD-7-1  
San Francisco, CA 94105

Re: Work Plan for Additional Source Area Injection Activities  
Former TRW Microwave Site  
825 Stewart Drive, Sunnyvale, California

Dear Ms. Morash:

Northrop Grumman Systems Corporation (Northrop Grumman) is submitting the enclosed Work Plan for Additional Source Area Injection Activities for the former TRW Microwave site for your review and approval. The work plan was prepared to present the proposed approach for performing additional injections of a substrate to stimulate in situ bioremediation in the former source area. As described in the work plan, these activities will be performed in conjunction with the source area excavation work that is currently underway at the site.

If you have any questions, please do not hesitate to contact me at 703-280-4035, or our project manager, Linda Niemeyer, at 760-944-9490.

Sincerely,



Joseph P. Kwan  
Corporate Director, Environmental Remediation  
on behalf of Northrop Grumman Systems Corporation

Enclosure: Work Plan for Additional Source Area Injection Activities

cc: Rebecca Mora - AECOM  
Linda Niemeyer - Watermark



**WORK PLAN FOR  
ADDITIONAL SOURCE AREA  
INJECTION ACTIVITIES**

**FORMER TRW MICROWAVE SITE  
825 STEWART DRIVE  
SUNNYVALE, CALIFORNIA**

**November 11, 2014**

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**WORK PLAN FOR  
ADDITIONAL SOURCE AREA INJECTION ACTIVITIES**

**FORMER TRW MICROWAVE SITE  
825 STEWART DRIVE  
SUNNYVALE, CALIFORNIA**

**November 11, 2014**

**Prepared by:**

**AECOM  
999 W. Town and Country Road  
Orange, CA 92868-4713**

**Prepared for:**

**Northrop Grumman Systems Corporation  
2980 Fairview Park Drive  
Falls Church, VA 22042**



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**Rebecca Mora  
Senior Engineer/Project Manager**

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## 1.0 INTRODUCTION

On behalf of Northrop Grumman Systems Corporation (Northrop Grumman), AECOM has prepared this *Work Plan for Additional Source Area Injection Activities* (Work Plan) for the former TRW Microwave site located at 825 Stewart Drive in Sunnyvale, California (Site).

The purpose of this Work Plan is to present the approach for performing additional injection activities in the vicinity of the former excavation. Specifically, the injections will target residual chlorinated solvent-impacted material under the building footing near the eastern portion of the former excavation. The current excavation work being performed at the Site per the *Well Destruction and Source Removal Work Plan* (AECOM, 2014a) cannot address material underneath the footing.

### 1.1 Background

Figure 1 presents a Site plan including the existing groundwater monitoring well locations and the location of the former underground storage tank (UST) area. In 1984, approximately 200 cubic yards of volatile organic compound (VOC)-impacted soils were removed from the former on-site source area. The resulting excavation was approximately 19 feet by 16 feet and extended to a depth of approximately 13 to 18 feet below ground surface (bgs) (Figure 2). The eastern and southern extents of the excavation were limited by the outer wall of the building that existed at that time (outlined in red on Figure 3). Also, a de-ionizing water processing area was located to the west of the UST which limited further excavation to the west. Due to these limitations, VOC-impacted soil was documented as remaining in the 1984 report by Weiss Associates (WA) (WA, 1984). Specifically, impacted soil was documented as remaining in the sidewalls beneath the footings of the former building.

Between 2001 and 2003, the Site building exterior was remodeled. As part of this remodeling, a portion of the building was demolished (shown in red on Figure 3) and a new structure contiguous with the existing structure was constructed (shown in blue on Figure 3). This new portion of the building overlies the previous excavation cavity and, consequently, the footing for the new structure is located over a portion of the former excavation.

To address elevated concentrations of VOCs in groundwater near the on-site source area, an enhanced anaerobic bioremediation (EAB) pilot program was initiated in 2000 within and surrounding the former source area excavation and then expanded in 2005 to include the area immediately down gradient of the former source area. These initial EAB activities (where Hydrogen Release Compound [HRC®] was injected) increased the rate of VOC biodegradation occurring within the former site source area and accelerated VOC attenuation rates across the downgradient portions of the Site. Additional source area remedial activities were performed in October and November 2010, including injection of emulsified vegetable oil (EVO) and neat vegetable oil to generate reducing conditions in the vicinity of the former source area excavation and sequester VOCs within the neat oil introduced into the pea gravel-filled excavation. Although the EVO and neat vegetable oil

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injections were effective at limiting downgradient migration of high VOC concentrations, as indicated by groundwater sampling results from well T-2A, VOC concentrations in groundwater and vegetable oil samples from the Eductor indicate that residual source material is likely present in the vicinity of the former site source area excavation. The *Five-Year Status and Effectiveness Evaluation Report* (AECOM, 2014b) provides a summary of EAB activities and remediation results.

Per the *Well Destruction and Source Removal Work Plan* (AECOM, 2014a), source area excavation activities using 30-inch diameter augers commenced in October 2014 and are currently underway at the Site. Prior to and during these excavation activities, soil borings were advanced and soil samples were collected at various depths to further evaluate the extent of residual VOC contamination in the source area and guide the excavation efforts. These soil borings included three angled soil borings (SB-8, SB-9, and SB-10) that were advanced beneath the building footing, as shown on Figure 4. The soil sample results from these angle borings, which are provided in Table 1, indicate that residual VOC-impacted material is present beneath the building footing. This material is not accessible via the excavation activities currently underway, and thus an alternative approach to address this area is proposed, as described in this work plan. Table 1 provides a complete summary of soil analytical results from angle borings SB-8, SB-9, and SB-10 and Figure 4 includes a summary of the maximum concentrations detected in each boring and the depth interval for those detections.

## **2.0 OBJECTIVE AND WORK PLAN ORGANIZATION**

The objective of the injection activities proposed in this Work Plan is to treat VOC-impacted material below the building footing, in the vicinity of the former Site source area, using EAB.

This work plan is organized as follows;

- 3.0 Description of EAB Technology
- 4.0 Basis of Design
- 5.0 Injection Approach
- 6.0 Monitoring and Reporting
- 7.0 References

## **3.0 DESCRIPTION OF EAB TECHNOLOGY**

Because tenant improvements inside the Site building will commence immediately following EAB injection activities, additional injections/optimization will not be possible in the future. Therefore, the EAB amendments proposed for this application (EVO, buffer, and bioaugmentation culture) were selected to optimize treatment performance and are described further below.

Based on previously successful execution at the Site, injection of EVO is proposed to stimulate EAB of VOCs beneath the building footing. The primary difference with this proposed application, compared to its previous use at the Site, is that the EVO will be injected into the subsurface using direct push technology (DPT) rather than through the

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Eductor. DPT injection has been used successfully at other areas of the Site to inject a variety of amendments (e.g., HRC® and Anaerobic Biochem Plus).

Based on the previous EVO injection, this approach is successful at:

- Enhancing distribution of electron donor due to the non-viscous nature of EVO,
- Generating geochemical conditions conducive to EAB, and
- Providing a long-lasting electron donor for EAB.

EVO is one of the more common slow-release electron donors for in situ bioremediation of chlorinated VOCs and is developed using food processing technologies. Surfactants (emulsifiers) are added to the oil (typically soybean oil) and the oil is mixed with water by a high-energy shearing process (most commonly homogenization) to create a stable oil-in-water emulsion. The benefit of an oil-in-water emulsion is the ability to readily inject the product throughout the intended treatment zone due to its small oil droplet size. EVO is available from multiple vendors and usually includes a fast-release electron donor component, such as sodium lactate. Commercially available EVO products are generally sold as a concentrate. The percentage of oil in these concentrated emulsions can vary, but is commonly 45% to 60%. Prior to injection, this concentrated EVO is typically diluted based on the desired injection volume and mass of EVO required (typical range for dilute solutions is 5% to 25% EVO by volume). A Material Safety Data Sheet (MSDS) for Newman Zone® from Remediation & Natural Attenuation Services, Inc. (RNAS) (the EVO that has been selected for this application) is included in Appendix A.

Based on previous injection of EVO at the Site, it is possible that a pH decrease after injection can be observed due to generation of fatty acids as the EVO degrades, as well as to hydrochloric acid generated during dechlorination of chlorinated solvents. Therefore, a buffer will be added to the EVO solution to maintain a neutral pH for optimal biodegradation. A combination of Neutral Zone® from RNAS, a colloidal calcium carbonate buffer, and sodium bicarbonate is proposed for this application. This buffer combination was selected because (1) the sodium bicarbonate addresses immediate acid generation while the Neutral Zone product lasts longer in the subsurface, and (2) it will not excessively increase pH, as is possible when using a base.

*Dehalococcoides*, spp. (Dhc), is the only known microorganism that can completely degrade tetrachloroethene and trichloroethene (TCE) to the non-toxic end-product, ethene. Based on previous EAB activities and monitoring at the Site, Dhc is known to be naturally present in the vicinity of the source area and therefore bioaugmentation with a culture containing Dhc was not previously performed at the Site. However, based on the objective of optimizing performance of the proposed EAB injections, bioaugmentation is proposed to further enhance the dechlorinating microbial population. The Low-pH KB-1® culture from SiREM is proposed for this application because it contains Dhc and has been shown to effectively degrade chlorinated solvents under neutral pH conditions, and also down to a pH of 5.5. While a buffer is being injected to mitigate pH excursion, this culture was selected as a cost-effective and conservative measure to ensure optimal EAB.

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## 4.0 BASIS OF DESIGN

As discussed in Section 1.1, the design for this application was based on analytical results from recent soil samples collected as part of the source area excavation program. As shown on Figure 4, the eastern extent of the on-going source area excavation is limited by the building footing, which extends approximately 6 feet west of the interior wall. Based on previous source area characterization work, the footing is at least 4 feet thick and underlain by a hard layer (likely native soil mixed with cement) of unknown thickness. Previous attempts to core through the concrete in this area have not been successful. Therefore, EVO will be injected adjacent to the west edge of the footing using DPT and a directional injection tool (Figure 5) that will direct amendments to the east, underneath the footing. For additional coverage, EVO will also be injected adjacent to the east side of the interior building wall and directed west under the building footing. Because amendment distribution using this technique is not radial, injection points are spaced closer than typical and are approximately 2.5 feet apart for this application. Using injection pressures between 200 and 500 pounds per square inch, this technology is capable of achieving a 6-foot area of influence in the targeted direction. Figure 6 shows the proposed injection point locations and anticipated distribution of injected amendments.

The volume of injected EVO solution was calculated based on a percentage of the targeted pore volume. The required quantity of EVO in the dilute EVO solution was then calculated based on the hydrogen demand of the treatment area.

The target treatment area is based on recent analytical results from soil borings indicating the presence of impacted soil to a depth of approximately 35 feet bgs. The original excavation in the vicinity of the footing was limited to 11 feet bgs (WA, 1984). Therefore, the targeted injection interval is from 10 feet bgs to 35 feet bgs. The length of the target treatment area is equivalent to the length of the original excavation (approximately 20 feet). The target width of the treatment area is based on injecting substrate from both the west and east sides of the building footing. Each injection direction will target 6 feet of distribution, resulting in a total width of 10 to 12 feet. Assuming a 20% porosity for silty sand, the total pore volume of the treatment area is 9,000 gallons. The targeted injection volume is approximately 20% of the effective pore volume, and thus approximately 1,800 gallons. The actual injection volume and injection locations may be modified in the field, based on Site conditions.

The required quantity of EVO in the injected EVO solution was calculated using the spreadsheet included in Appendix B (developed through the Environmental Security Technology Certification Program [ESTCP]) and was based on the current hydrogen demand exerted by the native electron acceptors (primarily dissolved oxygen, nitrate, sulfate, and carbon dioxide [estimated as the amount of methane produced]), and contaminants (primarily TCE, cis-1,2-dichloroethene, and vinyl chloride in the treatment area). Based on the calculations, a total of 710 pounds of soybean oil is required to fulfill the hydrogen demand. Because Newman Zone is approximately 46% soybean oil, approximately 2,400 pounds of Newman Zone will be required. In addition to EVO, Neutral Zone (1,185 pounds) and sodium bicarbonate (590 pounds) will also be added to the solution to keep the pH in the treatment area within the optimal zone for the Low-pH KB-1,

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as discussed in Section 3. The amount of buffer required was estimated based on the expected acid generation from reductive dechlorination and EVO fermentation.

Based on recommendations from SiREM, 6 liters of Low-pH KB1 will be injected into the targeted treatment area with the buffered EVO solution. To facilitate survival of the culture, oxygen will be removed from the makeup water using sodium sulfite.

## **5.0 INJECTION APPROACH**

All injection activities will occur within the area cleared by subsurface geophysics during previous source area investigations. The concrete floor has already been removed in this area due to the on-going excavation activities, so concrete coring will not be necessary. After completion of each injection point, the borehole will be backfilled with grout and/or bentonite. The vapor barrier will be patched using Viper® VaporPatch cross-woven polyethylene with peel-and-stick backing. A small volume of clean sand will be placed above the vapor barrier patch to provide separation between the barrier and the final concrete patch at the surface.

The buffered EVO solution and bioaugmentation culture will be injected by Vironex, Inc. (Vironex) using DPT. At each injection location, the amendments will be injected in 1- to 2-foot intervals proceeding from shallow to deep to minimize short circuiting of the injected material (daylighting).

During injection, flow rates and injection pressures will be monitored to verify that the amendments are entering the formation. Based on previous DPT injections at the Site, it is expected that the total planned injection volume of EVO solution will be injected into each interval. These injection procedures may be modified based on conditions encountered in the field.

During injection activities, air monitoring will be performed to monitor for VOCs and methane, hydrogen sulfide, and carbon monoxide (refer to attached task hazard analyses in Appendix C).

## **6.0 MONITORING AND REPORTING**

Per the *Well Destruction and Source Removal Work Plan* (AECOM, 2014a), all monitoring wells located inside the Site building will be abandoned, including those near the former Site source area. Therefore, post-injection monitoring will not be performed in the vicinity of the injections. However, semiannual groundwater monitoring of Site wells, including those located immediately downgradient of the Site building (Figure 1), will continue. The results of this monitoring will be used to evaluate the effects of both the proposed injection activities and the on-going excavation activities. Semiannual monitoring results will be reported in the annual groundwater monitoring reports for the Site.

## **7.0 REFERENCES**

AECOM, 2014a. *Well Destruction and Source Removal Work Plan*, Former TRW Microwave Facility, 825 Stewart Drive Sunnyvale, California. September 18.

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AECOM, 2014b. *Five-Year Status and Effectiveness Evaluation Report, January 2009 to December 2013*, Former TRW Microwave Facility, 825 Stewart Drive Sunnyvale, California. February 28.

Weiss Associates, 1984. *Ground Water Protection Study and Remedial Action Investigation*, TRW Microwave, 825 Stewart Drive, Sunnyvale, California. December 3.

## TABLE

**Table 1. Analytical Results from Soil Borings**

Soil Boring	Sample Depth (feet)	Sample Date	Volatile Organic Compounds (µg/kg) <sup>(a)</sup>			
			PCE	TCE	cDCE	VC
SB-8	5	10/23/14	394	1,750	98.8 J	ND<220
	10	10/23/14	44.4 J	382	2,160	33.0 J
	15	10/23/14	0.98 J	14.8	6.8	1.0 J
	20	10/23/14	ND<460	ND<460	ND<460	ND<460
	25	10/23/14	ND<210	22.8 J	ND<210	ND<210
	30	10/23/14	ND<140	162	237	ND<140
	35	10/23/14	ND<230	33.9 J	542	58.5 J
SB-9	5	10/23/14	84.6 J	899	ND<150	ND<150
	10	10/23/14	302 J	6,320	816	ND<760
	15	10/23/14	288	2,730	325	ND<270
	20	10/23/14	ND<590	ND<590	ND<590	ND<590
	25	10/23/14	ND<220	ND<220	ND<220	ND<220
	30	10/23/14	ND<200	36.2 J	ND<200	ND<200
SB-10	5	10/23/14	1.6 J	10.5	9.3	ND<4.9
	10	10/23/14	1.5 J	9.7	11.4	3.9 J
	15	10/23/14	36.5 J	152 J	112 J	ND<220
	20	10/23/14	ND<800	ND<800	ND<800	ND<800
	25	10/23/14	ND<5	4.9 J	ND<5	2.5 J
	30	10/23/14	ND<170	25.7 J	331	ND<170

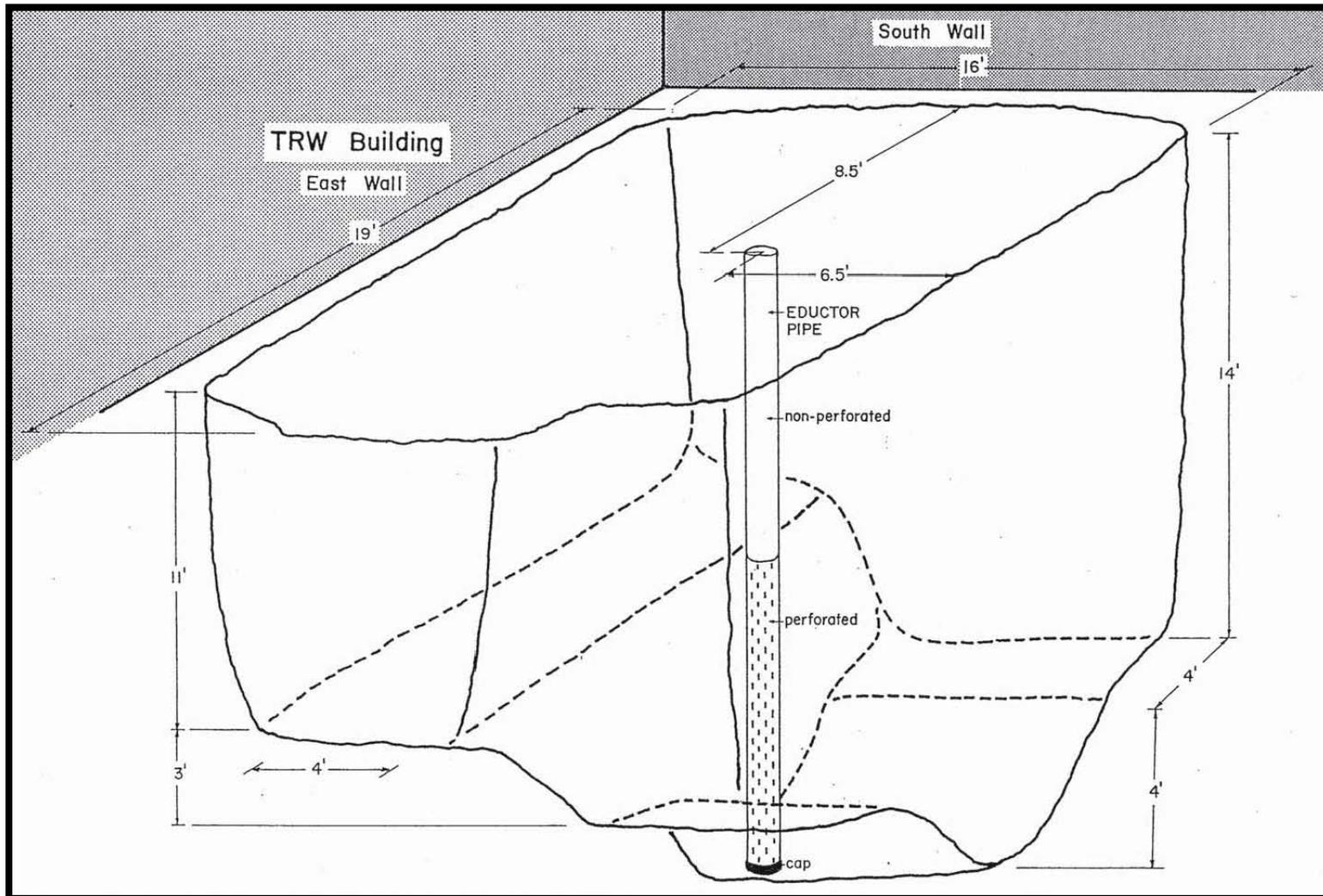
**Notes:**

<sup>(a)</sup> Volatile organic compounds tested using SW846 8260B. "J" indicates an estimated concentration. "ND" indicates the compound was not detected above the reporting limit.

µg/kg            micrograms per kilogram  
cDCE            cis-1,2-dichloroethene  
PCE             tetrachloroethene  
SLs              screening levels  
TCE              trichloroethene  
USEPA          United States Environmental Protection Agency  
VC               vinyl chloride

## FIGURES

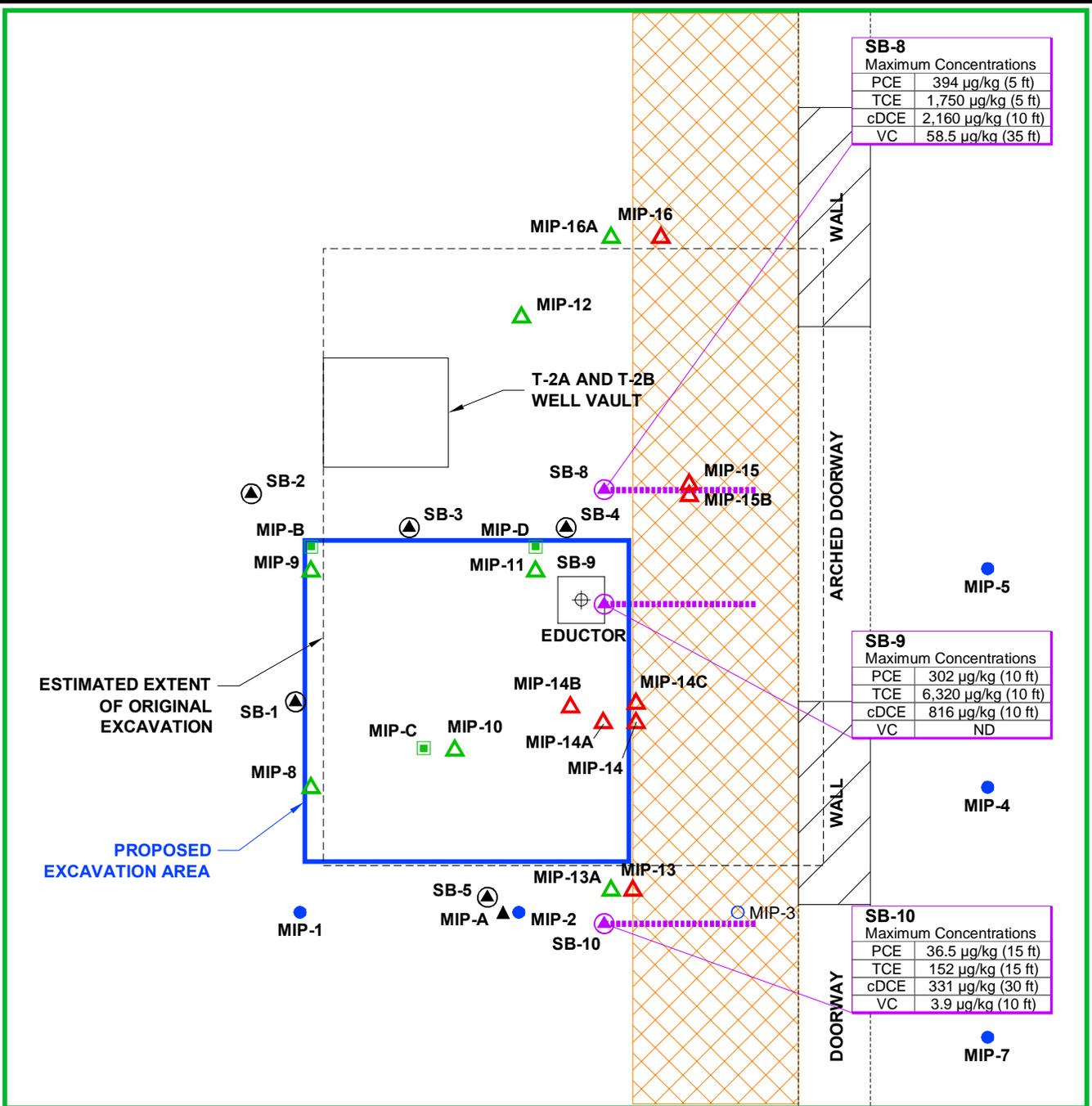




Adapted from Weiss Associates, 1984

	Former TRW Microwave Facility	
	<b>Waste Solvent Tank Excavation Diagram</b> (from Weiss Associates, 1984)	<b>FIGURE 2</b>





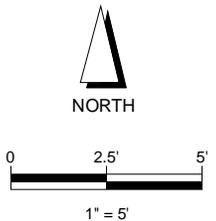
Inset A - See Figure 3

**Legend**

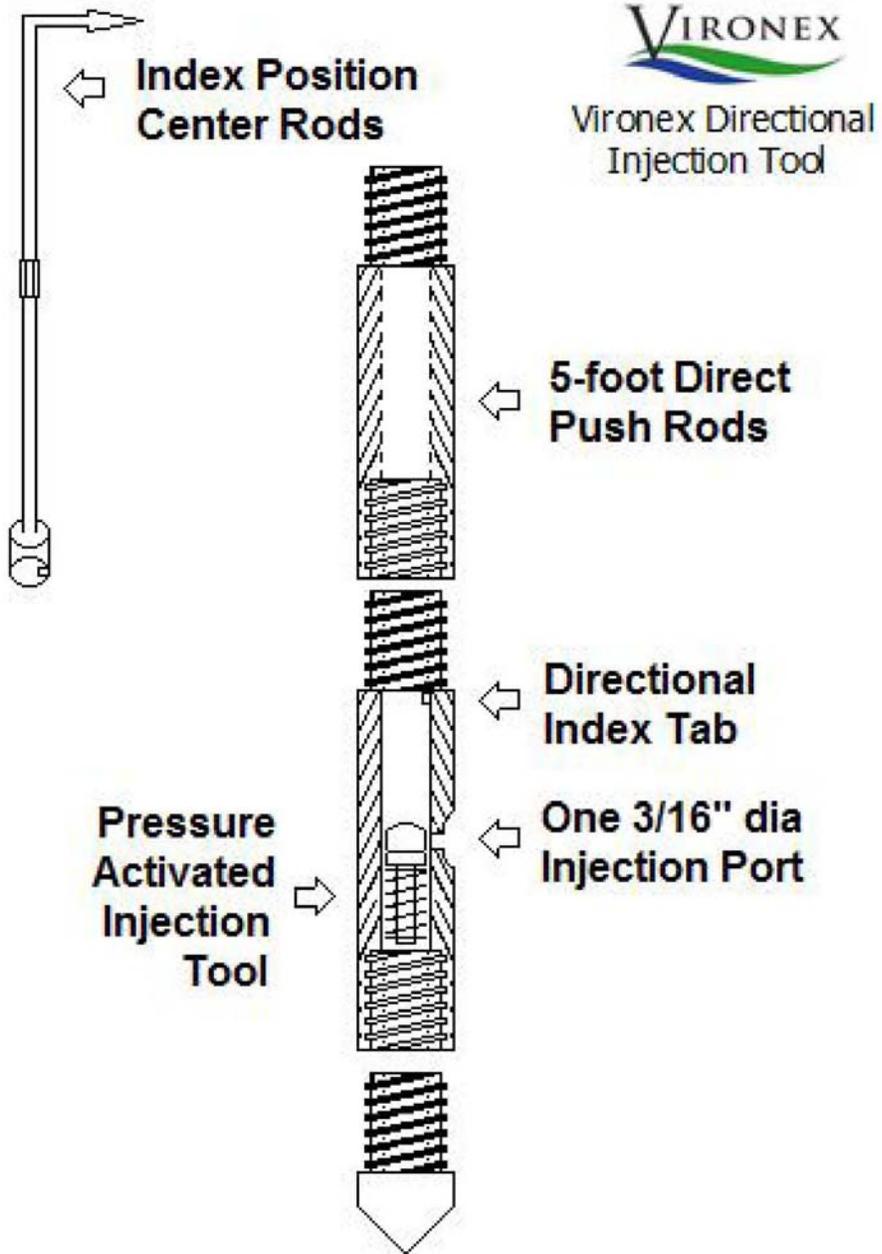
- Borehole Location (October 2014)
- MIP Locations (July 2014)
- Confirmation Borehole Location (July 2014)
- Attempted MIP Location (July 2014)
- MIP Locations (July 2013)
- Attempted MIP Location (Concrete more than 30 inches thick) (July 2013)
- Continuous Core and Soil Sampling Location (July 2013)
- Angled Boring Location (October 2014)
- Angled Boring Path (Terminated at 30 feet below ground surface)
- Assumed Footing

**Abbreviations**

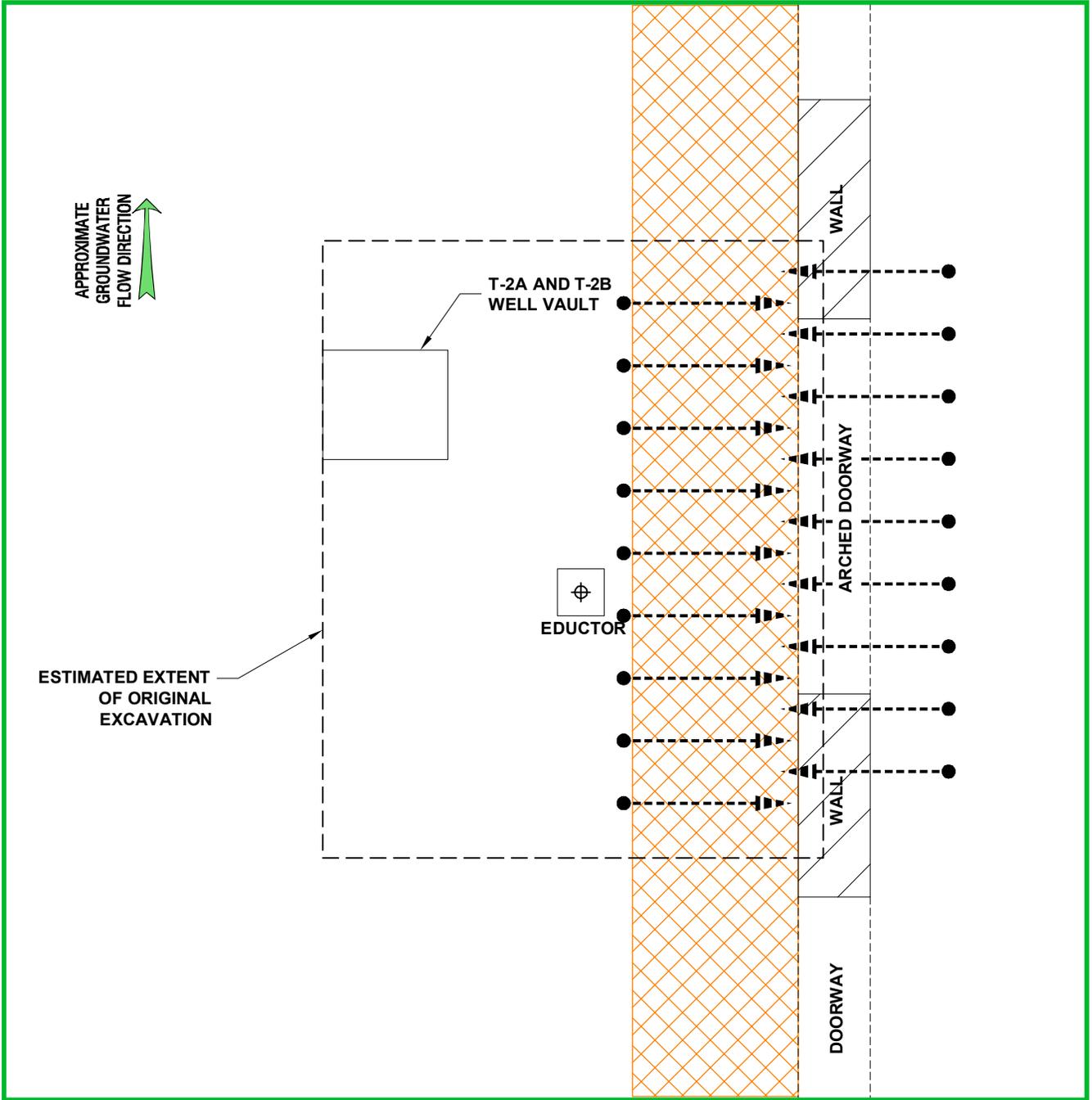
- µg/kg micrograms per kilogram
- cDCE cis-1,2-dichloroethene
- ft feet
- MIP membrane interface probe
- PCE tetrachloroethene
- TCE trichloroethene
- VC vinyl chloride



Former TRW Microwave Facility	
<b>MIP and Soil Boring Locations, and Proposed Excavation Area</b>	
Date: 11-14	<b>NORTHROP GRUMMAN</b>
Project No. 60238860	
Figure <b>4</b>	



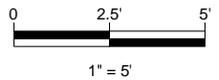
	Former TRW Microwave Facility	<b>FIGURE 5</b>
	<b>Vironex Directional Injection Tool</b>	



Inset A - See Figure 3

**Legend**

- Proposed Injection Locations
- > Injection Direction
- ▨ Assumed Footing



Former TRW Microwave Facility	
<b>Proposed Injection Locations</b>	
Date: 11-14	<b><i>NORTHROP GRUMMAN</i></b>
Project No. 60238860	
Figure <b>6</b>	

## **APPENDICES**

# **APPENDIX A**

MATERIAL SAFETY DATA SHEETS FOR AMENDMENTS

Remediation and Natural Attenuation Services Incorporated  
 6712 West River Road  
 Brooklyn Center, MN 55430

Product Information: 763-585-6191 Issue Date: June 14, 2013

**Section 1: IDENTIFICATION**

- 1.1 Product Name: Newman Zone -Nonionic Formulation 190-6725
- 1.2 Product Type: Edible Industrial Nutrient for Microbial Organisms
- 1.3 Hazard Rating: Health: 1 Fire: 1 Reactivity: 1
- 1.4 Formula: Proprietary

-----  
 Substances Subject to SARA 313 Reporting Are Indicated by "#"  
 -----

It is our opinion that the above named product does not meet the definition of "hazardous Chemical" as defined in the OSHA "Hazard Communication Standard" regulation 29 CFR 1910.1200. This material Safety Data Sheet is provided as general information for health and safety guidelines.

**Section 2: INGREDIENTS/COMPOSITION**

	CAS No.	%	PEL	TWA
Soybean Oil (food grade)	8001-22-7	46	15(Mist)	10(Mist)
Sodium-L-Lactate	867-56-1	4		
Food Additives/Emulsifiers/Preservatives (Proprietary)		<10		
Water		<45		

**EMERGENCY ONLY, 24-HOUR SERVICE: CHEMTREC: 1-800-424-9300**

**Section 3: PHYSICAL AND CHEMICAL CHARACTERISTICS**

This section completed per formulation ingredient data unless stated.

- Solubility: Dispersible in water (product)
- PH: 7.0-7.5 (product)
- Specific Gravity: 0.99 (product)
- Boiling Point: NA
- Vapor Pressure: NA
- Vapor Density: NA
- Percent Volatile By Volume (%): NA
- Evaporation Rate: NA
- Viscosity: 23.6 cps @ 68°F (Brookfield)(product)
- Product Appearance and Odor: White opaque liquid, vegetable oil odor.

=====  
**Section 4: FIRE AND EXPLOSION HAZARDS**

This section completed per formulation ingredient data unless stated.

4.1 Special Fire Hazards: Product - none, does not support combustion.

Flash Point: >540 degrees F (Pure Soybean Oil Closed Cup).

Flammable Limits

LEL ND

UEL ND

4.2 Fire Fighting Methods: Use method appropriate for surrounding fire.

4.3 Extinguishing Media: Dry Chemical or CO<sub>2</sub> Preferable; water may cause spattering or spreading.

=====  
**Section 5: HEALTH HAZARD DATA**

5.1 THIS PRODUCT IS USED FOR SOIL AND GROUND WATER REMEDIATION BUT IS FORMULATED USING FOOD AND FOOD GRADE ADDITIVES. PROCESSING, PACKAGING, SANITATION AND STORAGE OF THE PRODUCT FOLLOWS THE BEST PRACTICES USED FOR FOOD PRODUCTS.

5.2 Effects of Overexposure: NA

5.3 Emergency and First Aid Procedures: If inhaled, remove from contaminated atmosphere. For eye contact immediately flush eyes with large amounts of water. Ensure rinsing entire surface of eye & under lid. For skin contact wash affected areas thoroughly with soap and water. Seek medical help for persistent irritation.

5.4 Hydrolyzed soy protein has been identified by the United States Food and Drug Administration as a food allergen. Symptoms include swelling of the lips, stomach cramps, vomiting, diarrhea, skin hives, rashes, eczema and breathing problems.

5.5 Occupational Exposure Limits [8-hour time weighted averages (TWA)]:

	CAS No.	mg/m <sup>3</sup> OSHA PEL/ACGIH TLV
Soybean Oil (food grade)	8001-22-7	15(Mist)/10(Mist)

=====  
**Section 6: REACTIVITY DATA**

This section completed per formulation ingredient data unless stated.

6.1 Stability: Stable under normal conditions.

6.2 Conditions to Avoid: NA

6.3 Incompatibilities: None known

6.4 Hazardous Decomposition Products: Product - None identified.  
 Ingredients - Carbon oxides. Biological decomposition (spoilage) may result in offensive odors.

6.5 Hazardous Polymerization; None known

=====  
**Section 7: SPILL OR LEAK PROCEDURES**

This section completed per formulation ingredient data unless stated.

- 7.1 Spill Response: Water dispersible. Same as for vegetable oil spills: isolate spill, prevent from entering waterways, and sewer systems. Sorb or remove spilled materials as soon as possible. Oils and specific quantities of oils may be reportable under federal, state, or local regulations.
- 7.2 Waste Disposal Method: This product is not hazardous, however, wastes must be disposed in accordance with local, state or federal regulations. Consult with local sewer authority, or solid waste facility prior to disposition.

=====  
**Section 8: SPECIAL PRECAUTIONS**

No protective equipment is necessary under normal use conditions.

- 8.1 Eyes: If splashing may occur, eye protection recommended.
- 8.3 Skin: Wear impervious gloves for prolonged or repeated exposure.
- 8.4 Respiratory: Avoid breathing mists of this product

=====  
**Section 9: TRANSPORTATION PRECAUTIONS**

This section completed per formulation ingredient data unless stated.

- 9.1 Transportation Considerations: This product is not classified as dangerous in the meaning of transport regulations. Shippers and transporters may need to meet packaging and transportation requirements for certain oils and respective quantities under CFR 49 Part 130.

The above information is believed to be correct with respect to the formula used to manufacture the product in the country of origin. As data, standards, and regulations change, and conditions of use and handling are beyond our control, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE AS TO THE COMPLETENESS OR CONTINUING ACCURACY OF THIS INFORMATION.

### 1. PRODUCT IDENTIFICATION

<b>TRADE NAME (AS LABELED):</b>	<b>Neutral Zone</b>
<b>SYNONYMS:</b>	Buffer solution
<b>CAS#:</b>	Mixture
<b>PRODUCT USE:</b>	Neutral Zone is a colloidal calcium carbonate buffer product that consists of food grade precipitated calcium carbonate. This product is used to maintain neutral pH of our bioremediation products.
<b>CHEMICAL SHIPPING NAME/CLASS:</b>	Ethanol Solution, Class 3, Flammable Liquid, PGIII
<b>U.N. NUMBER:</b>	UN1170
<b>MANUFACTURER'S NAME:</b>	<b>RNAS Remediation Products</b>
<b>ADDRESS:</b>	6712 West River Road, Brooklyn Center, MN 55430
<b>BUSINESS PHONE:</b>	1-763-585-6191
<b>EMERGENCY PHONE:</b>	1-800-424-9300 (Chemtrec 24 Hr Service – Emergency Only)
<b>DATE OF CURRENT REVISION:</b>	May 27, 2014
<b>DATE OF LAST REVISION:</b>	May 20, 2013

### 2. HAZARD IDENTIFICATION

**EMERGENCY OVERVIEW:** This product is an opaque white slurry (light) with a slight alcohol odor.

**Health Hazards:** Prolonged or repeated exposure may cause irritation to skin. May cause irritation to eyes upon contact. Inhalation of vapors/sprays or mist may cause respiratory irritation. Ingestion of large amounts of this product may cause gastrointestinal irritation.

**Flammability Hazards:** This product is a Flammable liquid and vapors with a flash point of 130°F (54°C)

**Reactivity Hazards:** None known

**Environmental Hazards:** The Environmental effects of this product have not been investigated. Release of this product is not anticipated to have significant adverse effects in the aquatic environment.

US DOT SYMBOLS



CANADA (WHMIS) SYMBOLS



EUROPEAN and (GHS) Hazard Symbols



Signal Word: **Warning!**

#### EU LABELING AND CLASSIFICATION:

This product does meet the definition of a hazardous substance or preparation as defined by the European Union Council Directives 67/548/EEC, 1999/45/EC, 1272/2008/EC and subsequent Directives.

#### EU HAZARD CLASSIFICATION OF INGREDIENTS PER DIRECTIVE 1272/2008/EC:

**EC# 207-439-9 This substance is not classified in the Annex I of Directive 67/548/EEC**

**EC# 200-578-6 Annex I Index# 603-002-00-5**

Substances not listed either individually or in group entries must be self classified.

#### OSHA HAZARD CLASSIFICATION:

These chemicals are considered hazardous by OSHA

#### Component(s) Contributing to Classification(s)

Ethanol

#### GHS Hazard Classification(s):

Flammable Liquid Category 3

#### Hazard Statement(s):

H226: Flammable liquid and vapor

#### Precautionary Statement(s):

P210: Keep away from heat/sparks/open flames/ hot surfaces. No Smoking

P233: Keep container tightly closed.

P280: Wear protective gloves/eye protection/face protection.

**HEALTH HAZARDS OR RISKS FROM EXPOSURE:**

**SYMPTOMS OF OVEREXPOSURE BY ROUTE OF EXPOSURE:** The most significant routes of overexposure for this product are by contact with skin or eyes, inhalation of vapors and ingestion. The symptoms of overexposure are described below.

**ACUTE:**

**INHALATION:** Not expected to cause adverse health effects when used as intended. Inhalation of vapors/mist/spray may cause respiratory irritation.

**CONTACT WITH SKIN:** Not expected to cause adverse health effects when used as intended. Prolonged and repeated contact may cause irritation to skin.

**EYE CONTACT:** Direct eye contact can cause irritation with redness, tearing and blurred vision.

**INGESTION:** Under normal conditions of intended use, this material is not expected to be an ingestion hazard. Ingestion of large quantities may cause gastrointestinal irritation, nausea and vomiting.

**CHRONIC:** None known

**TARGET ORGANS:** **Acute:** Skin, Respiratory System and Eyes      **Chronic:** None known

### 3. COMPOSITION AND INFORMATION ON INGREDIENTS

Hazardous Ingredients:	WT%	CAS#	EINECS #	Hazard Classification	Risk Phrases
Calcium Carbonate Food Grade	45 – 55%	471-34-1	207-439-9	None	None Known
Ethanol	1 – 6%	64-17-5	200-578-6	[F] Flammable	R11
Balance of other ingredients is less than 1% in concentration (or 0.1% for carcinogens, reproductive toxins, or respiratory sensitizers).					

NOTE: ALL WHMIS required information is included in appropriate sections based on the ANSI Z400.1-2010 format. This product has been classified in accordance with the hazard criteria of the CPR and the SDS contains all the information required by the CPR, EU Directives and the Japanese Industrial Standard *JIS Z 7250: 2000*.

### 4. FIRST-AID MEASURES

**EYE CONTACT:** If product enters the eyes, open eyes while under gentle running water for at least 15 minutes. Seek medical attention if irritation persists.

**SKIN CONTACT:** Wash skin thoroughly with soap and water after handling. Seek medical attention if irritation develops and persists.

**INHALATION:** If breathing becomes difficult, remove victim to fresh air. If necessary, use artificial respiration to support vital functions. Seek medical attention.

**INGESTION:** If product is swallowed, call physician or poison control center for most current information. If professional advice is not available, do not induce vomiting. Never induce vomiting or give diluents (milk or water) to someone who is unconscious, having convulsions, or who cannot swallow. Seek medical advice. Take a copy of the label and/or SDS with the victim to the health professional.

**MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:** None known

**RECOMMENDATIONS TO PHYSICIANS:** Treat symptoms and eliminate overexposure.

### 5. FIRE-FIGHTING MEASURES

**FLASH POINT:** Non-Flammable with flash point 134°F (54°C)

**AUTOIGNITION TEMPERATURE:** Not Available

**FLAMMABLE LIMITS (in air by volume, %):** Lower NA Upper NA

**FIRE EXTINGUISHING MATERIALS:** Use fire extinguishing methods below:

Water Spray: No

Carbon Dioxide: Yes

Foam: Yes

Dry Chemical: Yes

Halon: Yes

Other: Any "C" Class

**UNUSUAL FIRE AND EXPLOSION HAZARDS:** Vapors may form an explosive mixture with air. Vapors can travel to a source of ignition and flash back. Do not use water jets. Water may cause spattering or spread the fire.

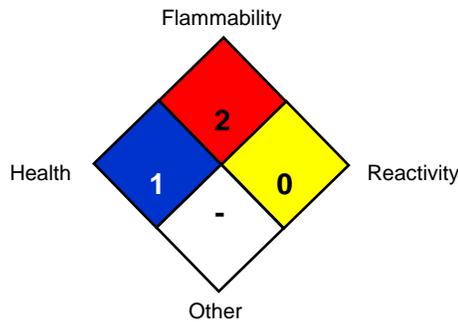
Explosion Sensitivity to Mechanical Impact: No

Explosion Sensitivity to Static Discharge: Yes

**Neutral Zone**

**SPECIAL FIRE-FIGHTING PROCEDURES:** Incipient fire responders should wear eye protection. Structural firefighters must wear Self-Contained Breathing Apparatus and full protective equipment. Isolate materials not yet involved in the fire and protect personnel. Move containers from fire area if this can be done without risk; otherwise, cool with carefully applied water spray. If possible, prevent runoff water from entering storm drains, bodies of water, or other environmentally sensitive areas.

### NFPA RATING SYSTEM



### HMIS RATING SYSTEM

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM			
HEALTH HAZARD (BLUE)	1		
FLAMMABILITY HAZARD (RED)	2		
PHYSICAL HAZARD (YELLOW)	0		
PROTECTIVE EQUIPMENT			
EYES	RESPIRATORY	HANDS	BODY
	See Sect 8		See Sect 8
For Routine Industrial Use and Handling Applications			

**Hazard Scale:** 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe \* = Chronic hazard

## 6. ACCIDENTAL RELEASE MEASURES

**SPILL AND LEAK RESPONSE:** Stop the flow of material, if this can be done safely. Eliminate sources of ignition. Contain discharged material. Absorb spill using an absorbent, non-combustible material such as earth, sand, or vermiculite. Place in a proper container for disposal. Dispose of in accordance with U.S. Federal, State, and local hazardous waste disposal regulations and those of Canada and its Provinces, those of Australia, Japan and EU Member States (see Section 13, Disposal Considerations).

## 7. HANDLING and STORAGE

**WORK PRACTICES AND HYGIENE PRACTICES:** As with all chemicals, avoid getting this product ON YOU or IN YOU. Use non-sparking hand tools and explosion-proof electrical equipment. Ensure adequate ventilation. Ensure adequate earthing. Wash thoroughly after handling this product. Use good hygiene practices.

**STORAGE AND HANDLING PRACTICES:** Store in original container. Keep container closed when not in use. Store in a cool, dry location away from heat sources or other sources of ignition. – No Smoking

## 8. EXPOSURE CONTROLS - PERSONAL PROTECTION

Chemical Name	CAS#	ACGIH TLV	OSHA TWA
Calcium Carbonate Food Grade	471-34-1	Not Listed	Not Listed
Ethanol	64-17-5	1000 ppm	1000 ppm

**VENTILATION AND ENGINEERING CONTROLS:** Use with adequate ventilation to ensure exposure levels are maintained below the limits provided above.

*The following information on appropriate Personal Protective Equipment is provided to assist employers in complying with OSHA regulations found in 29 CFR Subpart I (beginning at 1910.132) or equivalent standard of Canada, or standards of EU member states (including EN 149 for respiratory PPE, and EN 166 for face/eye protection), and those of Japan. Please reference applicable regulations and standards for relevant details.*

**RESPIRATORY PROTECTION:** Not normally required when using this product. Maintain airborne contaminant concentrations below guidelines listed above. If necessary, use only respiratory protection authorized in the U.S. Federal OSHA Respiratory Protection Standard (29 CFR 1910.134), equivalent U.S. State standards, Canadian CSA Standard Z94.4-93, the European Standard EN149, or EU member states.

### Neutral Zone

**EYE PROTECTION:** Safety glasses or goggles are recommended to avoid eye contact. If necessary, refer to U.S. OSHA 29 CFR 1910.133, Canadian Standards, and the European Standard EN166, Australian Standards, or relevant Japanese Standards.

**SKIN PROTECTION:** Wear impervious gloves for prolonged or repeated exposure as appropriate to task avoid when using this product. If necessary, refer to U.S. OSHA 29 CFR 1910.138, the European Standard DIN EN 374, the appropriate Standards of Canada, Australian Standards, or relevant Japanese Standards.

**BODY PROTECTION:** Use body protection appropriate to task being performed. If necessary, refer to appropriate Standards of Canada, or appropriate Standards of the EU, Australian Standards, or relevant Japanese Standards.

## 9. PHYSICAL and CHEMICAL PROPERTIES

**APPEARANCE (Physical State) and COLOR:** This product is an opaque white (Slurry) liquid with a slight alcohol odor.

**ODOR:** Slight

**ODOR THRESHOLD:** Not Available

**pH:** 9.5

**MELTING/FREEZING POINT:** Not Available

**BOILING POINT:** <99°C / 210°F @ 760 mmHg

**FLASH POINT:** 54°C / 130°F

**EVAPORATION RATE (n-BuAc=1):** Not Available

**FLAMMABILITY (SOLID, GAS):** Not Applicable

**UPPER/LOWER FLAMMABILITY OR EXPLOSION LIMITS:** Not Available

**VAPOR PRESSURE (mm Hg @ 20°C (68°F):** Similar to water 23 mmHg @ 25°C

**VAPOR DENSITY:** Not Available

**RELATIVE DENSITY:** Not Available

**SPECIFIC GRAVITY:** 1.45 @25°C

**SOLUBILITY IN WATER:** Dispersible in water

**WEIGHT PER GALLON:** Not Available

**PARTITION COEFFICIENT (n-octanol/water):** Not Available

**AUTO-IGNITION TEMPERATURE:** Not Available

**DECOMPOSITION TEMPERATURE:** Not Available

**VISCOSITY:** Not Available

## 10. STABILITY and REACTIVITY

**STABILITY:** Stable under conditions of normal storage and use.

**HAZARDOUS DECOMPOSITION PRODUCTS:** Thermal decomposition products include oxides of carbon and calcium oxide.

**MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE:** Strong oxidizing materials, strong acids and excessive heat.

**POSSIBILITY OF HAZARDOUS REACTIONS:** Will not occur.

**CONDITIONS TO AVOID:** Incompatible materials and ignition sources.

## 11. TOXICOLOGICAL INFORMATION

### TOXICITY DATA:

Ethanol CAS# 64-17-5

Draize test, rabbit, eye: 500 mg Severe;

Draize test, rabbit, eye: 500 mg/24H Mild;

Draize test, rabbit, skin: 20 mg/24H Moderate;

Inhalation, mouse: LC50 = 39 gm/m<sup>3</sup>/4H;

Inhalation, rat: LC50 = 20000 ppm/10H;

Oral, mouse: LD50 = 3450 mg/kg;

Oral, rabbit: LD50 = 6300 mg/kg;

Oral, rat: LD50 = 7060 mg/kg;<br>

**SUSPECTED CANCER AGENT:** Ingredients within this product are not found on the following lists: FEDERAL OSHA Z LIST, NTP, IARC, or CAL/OSHA and therefore are not considered to be, nor suspected to be, cancer-causing agents by these agencies.

**IRRITANCY OF PRODUCT:** No specific data available

**SENSITIZATION TO THE PRODUCT:** This product is not a skin and respiratory sensitizer

**REPRODUCTIVE TOXICITY INFORMATION:** No information concerning the effects of this product and its components on the human reproductive system.

## 12. ECOLOGICAL INFORMATION

ALL WORK PRACTICES MUST BE AIMED AT ELIMINATING ENVIRONMENTAL CONTAMINATION.

**ENVIRONMENTAL STABILITY:** No specific data available on this product. Does not potential for bioaccumulation.

**CHEMICAL EFFECT ON PLANTS, ANIMALS AND AQUATIC LIFE:** This product is not expected to cause significant harm to plants, animals or aquatic life.

**WATER ENDANGERMENT CLASS:** Water endangering in accordance with EU Guideline 91/155-EWG – Not Determined.

**SPECIFIC AVAILABLE COMPONENT INFORMATION:** No additional data available at this time.

## 13. DISPOSAL CONSIDERATIONS

**PREPARING WASTES FOR DISPOSAL:** Waste disposal must be in accordance with appropriate U.S. Federal, State, and local regulations, those of Canada, Australia, EU Member States and Japan.

**EU Waste Code:** Not determined

## 14. TRANSPORTATION INFORMATION

US DOT, IATA, IMO, ADR:

**U.S. DEPARTMENT OF TRANSPORTATION (DOT) SHIPPING REGULATIONS:** This product is classified (per 49 CFR 172.101) by the U.S. Department of Transportation, as follows.

**NOTE: Non-bulk containers (≤ 119 Gallons/450L) can be shipped via road or rail within the U.S. as a Non-Regulated Material per 49CFR173.120 (A flammable liquid with a flash point at or above 38 °C (100 °F) that does not meet the definition of any other hazard class may be reclassified as a combustible liquid. This provision does not apply to transportation by vessel or aircraft)**

**BULK SHIPMENTS GREATER THAN 119 GALLONS:**

<b>PROPER SHIPPING NAME:</b>	Ethanol Solution (Ethyl Alcohol Solution)
<b>HAZARD CLASS NUMBER and DESCRIPTION:</b>	Flammable liquid, Class 3
<b>UN IDENTIFICATION NUMBER:</b>	UN1170
<b>PACKING GROUP:</b>	PGIII
<b>DOT LABEL(S) REQUIRED:</b>	Flammable Class 3
<b>NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER:</b>	127
<b>RQ QUANTITY:</b>	None
<b>MARINE POLLUTANT:</b>	The components of this product are not designated by the Department of Transportation to be Marine Pollutants (49 CFR 172.101, Appendix B).

**INTERNATIONAL AIR TRANSPORT ASSOCIATION SHIPPING INFORMATION (IATA):** This product is considered as dangerous goods.

<b>PROPER SHIPPING NAME:</b>	Ethanol Solution (Ethyl Alcohol Solution)
<b>HAZARD CLASS NUMBER and DESCRIPTION:</b>	Flammable liquid, Class 3
<b>UN IDENTIFICATION NUMBER:</b>	UN1170
<b>PACKING GROUP:</b>	PGIII
<b>DOT LABEL(S) REQUIRED:</b>	Flammable Class 3
Limited QTY – Max net Qty per package 10.0 L Packaging Instruction Y344	
Max net Qty per Package Passenger and Cargo Aircraft 60L Packaging Instruction 355	
Max net Qty per Package Cargo Aircraft 220L Packaging Instruction 366	
ERG Code 3L	

**INTERNATIONAL MARITIME ORGANIZATION SHIPPING INFORMATION (IMO):** This product is considered as dangerous goods.

<b>PROPER SHIPPING NAME:</b>	Ethanol Solution (Ethyl Alcohol Solution)
<b>HAZARD CLASS NUMBER and DESCRIPTION:</b>	Flammable liquid, Class 3
<b>UN IDENTIFICATION NUMBER:</b>	UN1170
<b>PACKING GROUP:</b>	PGIII
<b>DOT LABEL(S) REQUIRED:</b>	Flammable Class 3

EUROPEAN AGREEMENT CONCERNING THE INTERNATIONAL CARRIAGE OF DANGEROUS GOODS BY ROAD (ADR): This product is considered by the United Nations Economic Commission for Europe to be dangerous goods.

### 15. REGULATORY INFORMATION

#### UNITED STATES REGULATIONS:

**U.S. SARA REPORTING REQUIREMENTS:** The components of this product are subject to the reporting requirements of Sections 302, 304, and 313 of Title III of the Superfund Amendments and Reauthorization Act as follows: None

**U.S. SARA THRESHOLD PLANNING QUANTITY:** There are no specific Threshold Planning Quantities for the components of this product. The default Federal SDS submission and inventory requirement filing threshold of 10,000 lbs (4,540 kg) therefore applies, per 40 CFR 370.20.

**U.S. CERCLA REPORTABLE QUANTITY (RQ):** None

**U.S. TSCA INVENTORY STATUS:** The components of this product are listed on the TSCA Inventory or are exempted from listing.

**OTHER U.S. FEDERAL REGULATIONS:** None

**CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):** Ingredients within this product are not on the Proposition 65 Lists.

#### CANADIAN REGULATIONS:

**CANADIAN DSL/NDSL INVENTORY STATUS:** The components of this product are on the DSL Inventory, or are exempted from listing.

**OTHER CANADIAN REGULATIONS:** Not applicable.

#### **CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS:**

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the SDS contains all of the information required by those regulations.

**CANADIAN WHMIS CLASSIFICATION and SYMBOLS:** This product is Class B Division 3 Combustible liquid per WHMIS Controlled Product Regulations

#### EUROPEAN ECONOMIC COMMUNITY INFORMATION:

This product does meet the definition of a hazardous substance or preparation as defined by the European Union Council Directives 67/548/EEC, 1999/45/EC, 1272/2008/EC and subsequent Directives.

See Section 2 for Details

**AUSTRALIAN INFORMATION FOR PRODUCT:** The components of this product are listed on the International Chemical Inventory list.

#### **JAPANESE INFORMATION FOR PRODUCT:**

**JAPANESE MINISTER OF INTERNATIONAL TRADE AND INDUSTRY (MITI) STATUS:** The components of this product are not listed as Class I Specified Chemical Substances, Class II Specified Chemical Substances, or Designated Chemical Substances by the Japanese MITI.

**JAPANESE ENCS INVENTORY:** The components of this product are on the ENCS Inventory as indicated in the section on International Chemical Inventories, below.

**POISONOUS AND DELETERIOUS SUBSTANCES CONTROL LAW:** No component of this product is a listed Specified Poisonous Substance under the Poisonous and Deleterious Substances Control Law.

#### **INTERNATIONAL CHEMICAL INVENTORIES:**

Listing of the components on individual country Chemical Inventories is as follows:

Asia-Pac: Listed or Exempt from listing

Australian Inventory of Chemical Substances (AICS): Listed or Exempt from listing

Korean Existing Chemicals List (ECL): Listed or Exempt from listing

Japanese Existing National Inventory of Chemical Substances (ENCS): Listed or Exempt from listing

Philippines Inventory of Chemicals and Chemical Substances (PICCS): Listed or Exempt from listing

Swiss Giftlist List of Toxic Substances: Listed or Exempt from listing

U.S. TSCA: Listed

**16. OTHER INFORMATION**

**ABBREVIATIONS AND ACRONYMS:**

EPA: United States Environmental Protection Agency  
ARD: European Agreement concerning the International Carriage of Dangerous Goods by Road  
IMDG: International Maritime Code for Dangerous Goods  
DOT: US Department of Transportation  
IATA: International Air Transport Association  
ACGIH: American Conference of Governmental Industrial Hygienists  
NFPA: National Fire Protection Association (USA)  
HMIS: Hazardous Materials Identification System (USA)

**PREPARED BY:** Paul Eigbrett – (**GHS MSDS Compliance PLUS**)

**DATE OF PRINTING:** May 27, 2014

The information contained herein is believed to be accurate but is not warranted to be so. Data and calculations are based on information furnished by the manufacturer of the product and manufacturers of the components of the product. Users are advised to confirm in advance of the need that information is current, applicable and suited to the circumstances of use. Remediation and Natural Attenuation Services Inc. assumes no responsibility for injury to vendee or third party person proximately caused by the material if reasonable safety procedures are no adhered to as stipulated in the data sheet. Furthermore, Remediation and Natural Attenuation Services Inc. assumes no responsibility for injury caused by abnormal use of this material even if reasonable safety procedures are followed.

**END OF SDS SHEET**

# **APPENDIX B**

ESTCP DESIGN TOOL OUTPUT

**Table S.5 Output for Substrate Requirements in Hydrogen Equivalents**

Site Name:

Example Site

[RETURN TO COVER PAGE](#)

**1. Treatment Zone Physical Dimensions**

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	12	feet	4	meters
Length (parallel to groundwater flow)	20	feet	6.1	meters
Saturated Thickness	25	feet	7.6	meters
Design Period of Performance	2	years	2	years

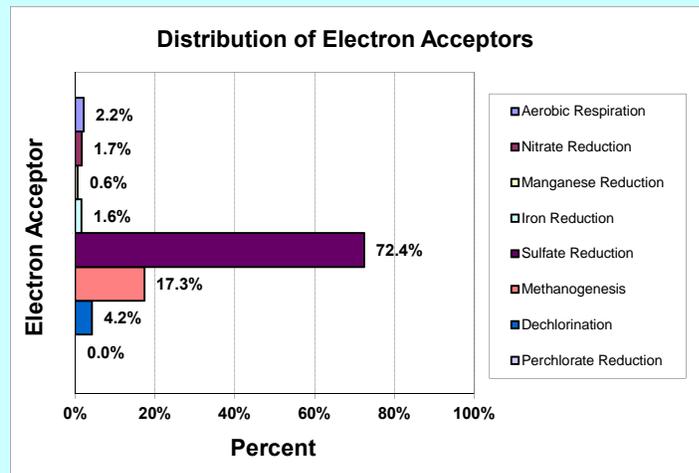
**2. Treatment Zone Hydrogeologic Properties**

	Values	Units	Values	Units
Total Porosity	0.3	percent	0.3	percent
Effective Porosity	0.2	percent	0.2	percent
Average Aquifer Hydraulic Conductivity	10	ft/day	3.5E-03	cm/sec
Average Hydraulic Gradient	0.01	ft/ft	0.01	m/m
Average Groundwater Seepage Velocity	0.50	ft/day	1.5E+01	cm/day
Average Groundwater Seepage Velocity	183	ft/yr	55.6	m/yr
Effective Treatment Zone Pore Volume	8,978	gallons	33,986	liters
Groundwater Flux (per year)	81,928	gallons/year	310,122	liters/year
Total Groundwater Volume Treated (over entire design period)	172,834	gallons total	654,230	liters total

**3. Distribution of Electron Acceptor Demand**

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	2.2%	0.908
Nitrate Reduction	1.7%	0.697
Sulfate Reduction	72.4%	30.273
Manganese Reduction	0.6%	0.265
Iron Reduction	1.6%	0.651
Methanogenesis	17.3%	7.247
Dechlorination	4.2%	1.752
Perchlorate Reduction	0.0%	0.000
<b>Totals:</b>	<b>100.00%</b>	<b>41.79</b>

Hydrogen demand in pounds/gallon:	2.42E-04
Hydrogen demand in grams per liter:	2.90E-02



**4. Substrate Equivalents: Design Factor =**

3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	5,812	528	1,942	as lactic acid
2. Molasses Product	4,435	370	1,845	as sucrose
3. Fructose Product	3,502	313	1,943	as fructose
4. Ethanol Product	1,791	260	993	as ethanol
5. Sweet Dry Whey (lactose)	2,762	sold by pound	1,341	as lactose
6. HRC®	2,123	sold by pound	1,178	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	1,090	140	756	as soybean oil
8. Emulsified Vegetable Oil	1,817	233	756	as soybean oil

**Notes:**

- Quantity assumes product is 60% sodium lactate by weight.
- Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
- Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
- Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
- Quantity assumes product is 70% lactose by weight.
- Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
- Quantity of neat soybean oil, corn oil, or canola oil.
- Quantity assumes commercial product is 60% soybean oil by weight.

# **APPENDIX C**

TASK HAZARD ANALYSES FOR INJECTION ACTIVITIES



**TASK HAZARD ANALYSIS (THA)**

Activity/Work Task: Direct Push Technology (DPT)	Overall Risk Assessment Code (RAC)				3																															
Project Location: Former TRW Microwave Facility 825 Stewart Drive Sunnyvale, California	<table border="1"> <thead> <tr> <th colspan="2" data-bbox="940 347 1402 505" rowspan="2">Risk Assessment Code (RAC) Matrix</th> <th colspan="4" data-bbox="1402 347 2011 386">Mishap Probability Subcategory</th> </tr> <tr> <th data-bbox="1402 386 1556 505">A. Likely to occur immediately or within a short period of time.</th> <th data-bbox="1556 386 1709 505">B. Probably will occur in time.</th> <th data-bbox="1709 386 1862 505">C. May occur in time.</th> <th data-bbox="1862 386 2011 505">D. Unlikely to occur.</th> </tr> </thead> <tbody> <tr> <td data-bbox="940 505 1066 591" rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">Hazard Severity Category</td> <td data-bbox="1066 505 1402 591">I. May cause death, permanent total disability, or loss of a facility/asset.</td> <td data-bbox="1402 505 1556 591" style="background-color: red; color: white; text-align: center;">1</td> <td data-bbox="1556 505 1709 591" style="background-color: red; color: white; text-align: center;">1</td> <td data-bbox="1709 505 1862 591" style="background-color: orange; color: white; text-align: center;">2</td> <td data-bbox="1862 505 2011 591" style="background-color: yellow; color: black; text-align: center;">3</td> </tr> <tr> <td data-bbox="1066 591 1402 711">II. May cause permanent partial disability, temporary total disability in excess of 90 days, or major property damage.</td> <td data-bbox="1402 591 1556 711" style="background-color: red; color: white; text-align: center;">1</td> <td data-bbox="1556 591 1709 711" style="background-color: orange; color: white; text-align: center;">2</td> <td data-bbox="1709 591 1862 711" style="background-color: yellow; color: black; text-align: center;">3</td> <td data-bbox="1862 591 2011 711" style="background-color: lightgreen; color: black; text-align: center;">4</td> </tr> <tr> <td data-bbox="1066 711 1402 802">III. May cause minor injury, occupational illness, or property damage.</td> <td data-bbox="1402 711 1556 802" style="background-color: orange; color: white; text-align: center;">2</td> <td data-bbox="1556 711 1709 802" style="background-color: yellow; color: black; text-align: center;">3</td> <td data-bbox="1709 711 1862 802" style="background-color: lightgreen; color: black; text-align: center;">4</td> <td data-bbox="1862 711 2011 802" style="background-color: cyan; color: black; text-align: center;">5</td> </tr> <tr> <td data-bbox="1066 802 1402 899">IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.</td> <td data-bbox="1402 802 1556 899" style="background-color: yellow; color: black; text-align: center;">3</td> <td data-bbox="1556 802 1709 899" style="background-color: lightgreen; color: black; text-align: center;">4</td> <td data-bbox="1709 802 1862 899" style="background-color: cyan; color: black; text-align: center;">5</td> <td data-bbox="1862 802 2011 899" style="background-color: cyan; color: black; text-align: center;">5</td> </tr> </tbody> </table>					Risk Assessment Code (RAC) Matrix		Mishap Probability Subcategory				A. Likely to occur immediately or within a short period of time.	B. Probably will occur in time.	C. May occur in time.	D. Unlikely to occur.	Hazard Severity Category	I. May cause death, permanent total disability, or loss of a facility/asset.	1	1	2	3	II. May cause permanent partial disability, temporary total disability in excess of 90 days, or major property damage.	1	2	3	4	III. May cause minor injury, occupational illness, or property damage.	2	3	4	5	IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.	3	4	5	5
Risk Assessment Code (RAC) Matrix								Mishap Probability Subcategory																												
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Date Prepared: 11/4/2014																																				
Prepared by (Name/Title): Holly Holbrook / Environmental Engineer																																				
Notes: (Field Notes, Review Comments, etc.) Level D Personal Protective Equipment (PPE): Hard Hat, Safety Glasses, Steel-Toe Boots and Safety Vest; Additional PPE: Sunscreen (SPF 30+), Hearing Protection, Nitrile Gloves																																				
	<p>Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above). Step 2: Identify the RAC (Probability/Severity) as 1, 2, 3, 4, or 5 for each "Hazard" on AHA. Annotate the overall RAC at the top of AHA.</p>				<p>RAC Definitions</p> <table border="1"> <tr><td style="background-color: red; color: white; text-align: center;">1- Critical</td></tr> <tr><td style="background-color: orange; color: white; text-align: center;">2-Serious</td></tr> <tr><td style="background-color: yellow; color: black; text-align: center;">3-Moderate</td></tr> <tr><td style="background-color: lightgreen; color: black; text-align: center;">4-Minor</td></tr> <tr><td style="background-color: cyan; color: black; text-align: center;">5-Negligible</td></tr> </table>	1- Critical	2-Serious	3-Moderate	4-Minor	5-Negligible																										
	1- Critical																																			
2-Serious																																				
3-Moderate																																				
4-Minor																																				
5-Negligible																																				

Job Steps	Hazards	Controls	RAC
1. Mobilize equipment and personnel to site.	<ul style="list-style-type: none"> <li>• Driving hazards</li> <li>• DPT rig (prior to operation)</li> </ul>	<ul style="list-style-type: none"> <li>• Inspect vehicles for defects and complete inspection form.</li> <li>• Implement safe driving practices to prevent transportation incidents.</li> <li>• Ensure that the drilling subcontractor has conducted inspections of the DPT rig and other equipment before placement at site and prior to operation. Obtain a Certification of Machinery and Mechanized Equipment Inspection form certifying equipment is in proper working order prior to the start of work.</li> <li>• Ensure subcontractor has inspected, and documented the inspection of support equipment (i.e., water truck and forklift) prior to placement on the site.</li> </ul>	3
2. Hold Tailgate Safety Briefing, review applicable THAs and standard operating procedures (SOPs); Inspect and don PPE; Inspect tools and equipment.	<ul style="list-style-type: none"> <li>• Incorrect PPE usage</li> <li>• Equipment malfunction</li> <li>• Lack of knowledge of tasks being performed</li> </ul>	<ul style="list-style-type: none"> <li>• Site Safety and Health Officer (SSHO) should check that required PPE is being used properly, including sunscreen with minimum SPF of 30.</li> <li>• User (AECOM and/or Subcontract Personnel) should inspect equipment before use.</li> <li>• Discuss tasks to be performed by personnel, potential hazards and control measures.</li> <li>• Inform workers of emergency contact information and hospital route.</li> <li>• Ensure that all personnel are familiar with the location of any and all Emergency Shut-off switches on the drill rig prior to operation and maintain a suitable distance from the operating drilling.</li> <li>• Following daily safety briefing, have personnel sign attendance form which will be maintained onsite.</li> <li>• Complete tailgate safety meeting form daily and maintain a record on file</li> </ul>	5
3. Evaluate area for hazards (this should be performed regularly throughout the duration of the task).	<ul style="list-style-type: none"> <li>• Utilities</li> <li>• Slips, trips and falls</li> <li>• Heat or cold stress</li> <li>• Biological Hazards</li> <li>• Traffic</li> </ul>	<ul style="list-style-type: none"> <li>• Personnel should identify and take measurable cautionary steps to observe areas for hazards; Ensure that pathways are clear and free of obstruction prior to initiating work; Adhere to proper housekeeping practices.</li> <li>• Begin heat or cold stress monitoring and continue while work is performed.</li> <li>• Implement appropriate heat stress prevention procedures (e.g., drink plenty of fluids and use appropriate work/rest schedule) or cold stress prevention procedures (e.g., dress appropriately), as necessary.</li> <li>• Identify and delineate areas where poisonous plants, insects, and wildlife are or may be present.</li> <li>• Use appropriate PPE.</li> </ul>	4
4. DPT rig placement and set-up.	<ul style="list-style-type: none"> <li>• Unstable ground surface</li> <li>• Overhead hazards</li> </ul>	<ul style="list-style-type: none"> <li>• Perform underground utility clearance prior to mobilization</li> <li>• Survey the worksite for overhead hazards and place drilling rig at an adequate distance.</li> <li>• Use a spotter when backing into a location.</li> </ul>	2

Job Steps	Hazards	Controls	RAC
5. Advance DPT rods into subsurface.	<ul style="list-style-type: none"> <li>• Drill operation</li> <li>• Concrete coring</li> <li>• Noise</li> <li>• Muscle strain</li> <li>• High pressure hoses</li> <li>• Struck by/striking hazard</li> <li>• Pinch points</li> <li>• Hand and power tools</li> <li>• Airborne contaminants and gases</li> <li>• Slips, trips and falls</li> </ul>	<ul style="list-style-type: none"> <li>• Verify that operator is qualified and working in a safe manner.</li> <li>• Ensure that all personnel are familiar with the location of any and all Emergency Shut-off switches on the drill rig prior to operation and maintain a suitable distance from the operating drilling.</li> <li>• DPT operator needs to complete Drill Rig inspection form daily prior to initiating site activities.</li> <li>• Establish a 25-foot exclusion zone around the Drill Rig and applicable work area prior to operation.</li> <li>• Wear appropriate hearing protection as necessary.</li> <li>• Hand auger (or posthole dig) to five feet or auger refusal (whichever comes first) prior to drilling to confirm utilities not present.</li> <li>• Practice proper lifting and manual handling of materials and equipment, lift with the knees, seek assistance or employ additional handling equipment as needed.</li> <li>• Perform air monitoring for airborne contaminants using both a photo ionization detector (PID) and multi-gas meter. (See attached air monitoring requirements)</li> <li>• Ensure that all exhaust is properly vented to the exterior of the building.</li> <li>• Ensure that the building is well ventilated during all drilling activities.</li> <li>• Use appropriate PPE.</li> <li>• Be aware of pinch points and avoid moving parts.</li> <li>• Watch for slips, trips, and falls from MIP lines, exhaust lines, hydraulic/compressor lines, and sampling equipment.</li> <li>• Clearly mark/cover boreholes that have been recently grouted until the grout has time to cure and harden.</li> </ul>	1
6. Decontaminate equipment.	<ul style="list-style-type: none"> <li>• Muscle strain</li> <li>• Contaminant Exposure</li> <li>• Pressurized equipment and hoses</li> <li>• Exhaust fumes</li> <li>• Chemical splash/flying debris</li> </ul>	<ul style="list-style-type: none"> <li>• Proper lifting techniques will be used; proper tools will be used for decontamination.</li> <li>• Wear appropriate PPE, including goggles and/or face shield if chemical splashing is of concern.</li> <li>• Inspect drums and waste containers prior to use for damage or other issues which may compromise the container and allow for a release of material.</li> <li>• Place spent decontamination water in appropriate containers or drums.</li> <li>• Inspect hoses, valves, and pump prior to use.</li> <li>• Decontaminate in a well-ventilated area.</li> <li>• Establish a 25-foot exclusion zone around the decontamination area.</li> </ul>	3

Equipment to be Used	Training Requirements for Equipment/Qualified Personnel name(s)	Inspection Requirements
DPT/MIP  Manual tools  PID and RKI Eagle Multi-Gas Monitor	Competent Drill Rig Operator / Services provide by Subcontractors to be determined  Review SOPs/NA  SSHO/TBD	Machinery and Mechanized equipment inspection form completed prior to project start; daily inspections before use and complete drill rig inspection form  Inspect all tools prior to use  Calibrate and maintain monitoring instruments daily
<b>Pertinent SOPs:</b>		
S3NA-001-PR <i>Safe Work Standards and Rules</i> S3NA-002-PR <i>Stop Work Authority for Unsafe Work</i> S3NA-005-PR <i>Driver and Vehicle Safety Program</i> S3NA-203-PR <i>Emergency Response Planning, Field</i> S3NA-208-PR <i>Personal Protective Equipment Program</i> S3NA-210-PR <i>Project Safety Meetings</i> S3NA-305-PR <i>Hand and Power Tools</i> S3NA-307-PR <i>Housekeeping, Worksite</i> S3NA-308-PR <i>Manual Lifting, Field</i> S3NA-309-PR <i>Mobile or Heavy Equipment</i> S3NA-313-PR <i>Wildlife, Plants and Insects</i> S3NA-405-PR <i>Drilling, Boring, and Direct Push Probing</i>	S3NA-406-PR <i>Electrical Lines, Overhead</i> S3NA-417-PR <i>Utilities Underground</i> S3NA-505-PR <i>Cold Stress Prevention</i> S3NA-509-PR <i>Hazardous Waste Operations and Emergency Response</i> S3NA-510-PR <i>Hearing Conservation Program</i> S3NA-511-PR <i>Heat Stress Prevention</i> S3NA-519-PR <i>Respiratory Protection Program</i> S3NA-521-PR <i>Decontamination</i>	
<div style="display: flex; justify-content: space-between; align-items: flex-end;"> <div data-bbox="100 1057 646 1084">                         Prepared by: <u>Holly Holbrook / Environmental Engineer</u> </div> <div data-bbox="1050 1057 1218 1084">                         (Sign and Date):                     </div> <div data-bbox="1255 963 1648 1073"> </div> <div data-bbox="1717 1057 1837 1084">                         11/4/2014                     </div> </div>		

*Abbreviations*

HASP health and safety plan  
HSSE health, safety, security, environmental  
NA not applicable  
PID photo ionization detector  
PPE personal protective equipment

RAC risk assessment code  
SSHO site safety and health officer  
SPF sun protection factor  
SOP standard operating procedure  
TBD to be determined  
THA task hazard analysis



Instrument	Required For TASKS	Location	Frequency
<b>Photo Ionization Detector (PID)</b>	All tasks where exposure to volatile compounds is possible and when handling contaminated soil, groundwater etc	Breathing Zone	Continuous
		Work Area	Initial entry, as needed
<b>RKI Eagle/ Multi-gas Meter</b>	All activities where flammable or hazardous conditions may exist, including operating an engine and/or drilling inside a structure or enclosure (limited ventilation)	Breathing Zone	Continuous
		Work Area	Initial entry, as needed

Instrument	Substances Detected	ACTION LEVEL	ACTION
<b>Photo Ionization Detector (PID)</b>	Petroleum hydrocarbons, Organic Solvents in parts per million (ppm) relative to calibration gas	<2 ppm Isobutylene, sustained for over 5 minutes	No action
		2-5 ppm Isobutylene, sustained for over 5 mins	Use Draeger tube to check for presence of vinyl chloride (VC). If no, then no action. If VC is detected, Stop Work!, notify PM and Safety Professional
		> 5 ppm Isobutylene sustained for over 5 mins	Stop Work, notify PM and Safety Professional.
<b>RKI Eagle/Multi-gas Meter</b>			
CO	CO in ppm, no relative response when calibrated with carbon monoxide. Required for activities which produce CO, including operating an engine inside a structure or enclosure (limited ventilation)	< 10 ppm CO	Ventilate area and monitor continuously
		> 10 ppm CO	Stop Work! Turn off all equipment and evacuate work area
O <sub>2</sub>	O <sub>2</sub> in % concentration, no relative response when calibrated with oxygen. Required when measuring lower explosive (LEL) (sufficient O <sub>2</sub> needed for accurate readings) and when O <sub>2</sub> may be displaced by another gas/vapor such as CO.	<19 % O <sub>2</sub>	Stop Work! Oxygen deficient atmosphere. Adverse health effects will occur with prolonged exposure.
		> 23.5 % O <sub>2</sub>	Stop Work! Oxygen enriched atmosphere, flammable conditions may exist.
Hydrogen Sulfide (H <sub>2</sub> S)	H <sub>2</sub> S in ppm. Required when drilling may release H <sub>2</sub> S from the subsurface.	< 10 ppm > 10 ppm	No Action Stop Work! Notify PM and Safety Professional.
Methane (CH <sub>4</sub> )	CH <sub>4</sub> in ppm and % concentration. Required when drilling may release CH <sub>4</sub> from the subsurface.	<1 % >1 %	No Action Stop Work! CH <sub>4</sub> enriched atmosphere, flammable conditions may exist



**TASK HAZARD ANALYSIS (THA)**

Activity/Work Task: EVO Injection (oversight)	Overall Risk Assessment Code (RAC)				3
Project Location: Former TRW Microwave Facility 825 Stewart Drive Sunnyvale, California					
Date Prepared: 11/4/14					
Prepared by (Name/Title): Holly Holbrook / Environmental Engineer					
Notes: (Field Notes, Review Comments, etc.) Level D Personal Protection Equipment (PPE): Hard Hat, Safety Glasses, Steel-Toe Boots and Safety Vest; Additional PPE: Sunscreen (SPF 30+), Nitrile Gloves, Hearing Protection (as necessary) <b>Injection activities involve the use of a Direct Push Technology (DPT) rig. Refer to and follow the AHA for DPT drilling for all safety requirements during the use of the DPT rig, including air monitoring procedures.</b>					
Risk Assessment Code (RAC) Matrix		Mishap Probability Subcategory			
		A. Likely to occur immediately or within a short period of time.	B. Probably will occur in time.	C. May occur in time.	D. Unlikely to occur.
Hazard Severity Category	I. May cause death, permanent total disability, or loss of a facility/asset.	1	1	2	3
	II. May cause permanent partial disability, temporary total disability in excess of 90 days, or major property damage.	1	2	3	4
	III. May cause minor injury, occupational illness, or property damage.	2	3	4	5
	IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.	3	4	5	5
<p>Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above). Step 2: Identify the RAC (Probability/Severity) as 1, 2, 3, 4, or 5 for each "Hazard" on AHA. Annotate the overall RAC at the top of AHA.</p>					<p>RAC Definitions</p> <p>1- Critical</p> <p>2-Serious</p> <p>3-Moderate</p> <p>4-Minor</p> <p>5-Negligible</p>

Job Steps	Hazards	Controls	RAC
1. Mobilize equipment and personnel to site.	<ul style="list-style-type: none"> <li>• Driving hazards</li> </ul>	<ul style="list-style-type: none"> <li>• Inspect vehicles for defects and complete inspection form.</li> <li>• Implement safe driving practices to prevent transportation incidents.</li> </ul>	3
2. Hold Tailgate Safety Briefing, review applicable THAs and standard operating procedures (SOPs); Inspect and don PPE; Inspect tools and equipment.	<ul style="list-style-type: none"> <li>• Incorrect PPE usage</li> <li>• Equipment malfunction</li> <li>• Lack of knowledge of tasks being performed</li> <li>• Potential incidents and emergencies</li> </ul>	<ul style="list-style-type: none"> <li>• Site Safety and Health Officer (SSHO) should check that required PPE is being used, including sunscreen with minimum SPF of 30.</li> <li>• User (AECOM and/or Subcontract Personnel) should inspect equipment before use.</li> <li>• Discuss tasks to be performed by personnel, potential hazards and control measures.</li> <li>• Following daily safety briefing, have personnel sign attendance form which will be maintained onsite.</li> <li>• Inform workers of emergency contact information and hospital route.</li> <li>• Complete tailgate safety meeting form daily and maintain a record on file.</li> </ul>	5
3. Evaluate area for hazards (this should be performed regularly throughout the duration of the task).	<ul style="list-style-type: none"> <li>• Slips, trips and falls</li> <li>• Heat or cold stress</li> <li>• Biological Hazards</li> <li>• Traffic</li> </ul>	<ul style="list-style-type: none"> <li>• Personnel should take identify and take measurable cautionary steps to observe areas for hazards; ensure that pathways are clear and free of obstruction prior to initiating work; adhere to proper housekeeping practices.</li> <li>• Begin heat or cold stress monitoring and continue while work is performed.</li> <li>• Implement appropriate heat stress prevention procedures (e.g., drink plenty of fluids and use appropriate work/rest schedule) or cold stress prevention procedures (e.g., dress appropriately), as necessary.</li> <li>• Avoid contact with poisonous plants, insects, and wildlife.</li> <li>• Use delineators, cones, and/or caution tape to isolate the work area.</li> </ul>	3
4. Injection	<ul style="list-style-type: none"> <li>• Slips, trips, and falls</li> <li>• Pressurized Hoses</li> <li>• Surfacing of Injected Materials (Daylighting)</li> <li>• Contaminant Exposure</li> <li>• Hand and power tools</li> <li>• Muscle Strain</li> <li>• Noise</li> </ul>	<ul style="list-style-type: none"> <li>• Be aware of potential trip hazards.</li> <li>• Secure all high pressure hose connections with whip-checks and check all hoses for cracks/damage.</li> <li>• Inspect pressure gauges for damage.</li> <li>• Use pressure gauges at the pump and/or injection well heads to monitor pressure during injection.</li> <li>• Ensure employees are aware of the possibility for injected material to surface away from the well during injection. Continuously monitor the site for the daylighting of materials.</li> <li>• Wear appropriate personal protective equipment (PPE), including face shield and Tyvek or coveralls when handling process chemicals.</li> <li>• Use proper tools. Inspect tools for damage and other wear that may present a hazard during operation.</li> <li>• Practice proper lifting and manual handling of materials and equipment, lift with the knees, seek assistance or employ additional handling equipment as needed.</li> <li>• Use hearing protection as necessary.</li> </ul>	3

Job Steps	Hazards	Controls	RAC
5. Decontaminate equipment.	<ul style="list-style-type: none"> <li>• Muscle strain</li> <li>• Contaminant Exposure</li> </ul>	<ul style="list-style-type: none"> <li>• Proper lifting techniques will be used; proper tools will be used for decontamination.</li> <li>• Wear appropriate PPE.</li> <li>• Place spent decontamination water in appropriate containers or drums.</li> </ul>	3

Equipment to be Used	Training Requirements for Equipment/Qualified Personnel name(s)	Inspection Requirements
Injection Equipment	Subcontractor	Inspect all tools and equipment prior to use

**Pertinent SOPs:**

S3NA-001-PR	<i>Safe Work Standards and Rules</i>	S3NA-313-PR	<i>Wildlife, Plants and Insects</i>
S3NA-002-PR	<i>Stop Work Authority for Unsafe Work</i>	S3NA-505-PR	<i>Cold Stress Prevention</i>
S3NA-005-PR	<i>Driver and Vehicle Safety Program</i>	S3NA-509-PR	<i>Hazardous Waste Operations and Emergency Response</i>
S3NA-203-PR	<i>Emergency Response Planning, Field</i>	S3NA-510-PR	<i>Hearing Conservation Program</i>
S3NA-208-PR	<i>Personal Protective Equipment Program</i>	S3NA-511-PR	<i>Heat Stress Prevention</i>
S3NA-210-PR	<i>Project Safety Meetings</i>	S3NA-520-PR	<i>Spill Response - Incidental</i>
S3NA-305-PR	<i>Hand and Power Tools</i>	S3NA-521-PR	<i>Decontamination</i>
S3NA-307-PR	<i>Housekeeping, Worksite</i>		
S3NA-308-PR	<i>Manual Lifting, Field</i>		

Prepared by: Holly Holbrook / Environmental Engineer

(Sign and Date):

11/4/14

Abbreviations			
AHA	activity hazard analysis	RAC	risk assessment code
DAP	diammonium phosphate	SSHO	site safety and health officer
HASP	health and safety plan	SPF	sun protection factor
HSSE	health, safety, security, environmental	SOP	standard operating procedure
NA	not applicable	TBD	to be determined
PPE	personal protective equipment		

