Dear Mr. Kieling,

Please find attached the Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan Bulk Fuels Facility, Kirtland Air Force Base, New Mexico, dated October 2016. This work plan has been prepared to discuss the pilot test that will be implemented at Kirtland Air Force Base to investigate and augment anaerobic in situ bioremediation of ethylene dibromide in groundwater. The primary objective of this pilot test is to evaluate the extent to which potential treatment amendments for biostimulation and bioaugmentation enhance the biodegradation process. The pilot test will be evaluated through a comprehensive groundwater sampling regimen that assesses direct and indirect indicators of EDB biodegradation.

If you have any question or concerns, please contact Mr. Wayne Bitner at (505) 853-3484 or at ludie.bitner@us.af.mil or Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil.

Sincerely,

DAWN A. NICKELL, Colonel, USAF
Vice Commander

Attachment:
Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan, CD copy & Cover letter

cc:
NMED-EHD (Roberts, McQuillan), letter/CD
NMED-HWB (Agnew), letter/CD
NMED-GWQB (Pullen, Hunter), letter/CD
EPA Region 6 (King, Ellinger), letter/CD
AFCEC-CZRX (Bodour, Bitner, Clark), letter only
USACE-Omaha District Office (Ellender), letter only
USACE-ABQ District Office (Simpler, Phaneuf), letter only
Public Info Repository, AR/IR, and File, letter/CD
Colonel Dawn A. Nickell  
377 ABW/CV  
2000 Wyoming Blvd SE  
Kirtland AFB NM 87117-5000

Mr. John Kieling, Bureau Chief  
Hazardous Waste Bureau (HWB)  
New Mexico Environment Department (NMED)  
2905 Rodeo Park Drive East, Building 1  
Santa Fe NM 87505-6303

Dear Mr. Kieling

Please find attached the Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan Bulk Fuels Facility, Kirtland Air Force Base, New Mexico, dated October 2016. This work plan has been prepared to discuss the pilot test that will be implemented at Kirtland Air Force Base to investigate and augment anaerobic in situ bioremediation of ethylene dibromide in groundwater. The primary objective of this pilot test is to evaluate the extent to which potential treatment amendments for biostimulation and bioaugmentation enhance the biodegradation process. The pilot test will be evaluated through a comprehensive groundwater sampling regimen that assesses direct and indirect indicators of EDB biodegradation.

If you have any question or concerns, please contact Mr. Wayne Bitner at (505) 853-3484 or at ludie.bitner@us.af.mil or Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil.

Sincerely

[Signature]

DAWN A. NICKELL, Colonel, USAF  
Vice Commander

Attachment:  
Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan, CD copy & Cover letter

cc:  
NMED-EHD (Roberts, McQuillan), letter/CD  
NMED-HWB (Agnew), letter/CD  
NMED-GWQB (Pullen, Hunter), letter/CD  
EPA Region 6 (King, Ellinger), letter/CD  
AFCEC-CZRX (Bodour, Bitner, Clark), letter only  
USACE-Omaha District Office (Ellender), letter only  
USACE-ABQ District Office (Simpler, Phaneuf), letter only  
Public Info Repository, AR/IR, and File, letter/CD
Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan, Bulk Fuels Facility, Kirtland Air Force Base, New Mexico

This Ethylene Dibromide In Situ Biodegradation Pilot Test Work Plan (Work Plan) has been prepared by CB&I Federal Services LLC (CB&I) for the U.S. Army Corps of Engineers (USACE), Omaha District, under Contract No. W9128F-12-D-0003, Task Order 0025. The test described in this Work Plan will be implemented at the Kirtland Air Force Base (AFB) Bulk Fuels Facility (BFF) site.

1.0 BACKGROUND

The pilot test described herein is funded by the U.S. Air Force (USAF) to investigate anaerobic in situ bioremediation (ISB) of 1,2-dibromoethane (i.e., ethylene dibromide; EDB). ISB, with and without bioaugmentation, is a common remedial approach to treat chlorinated solvents such as trichloroethene, and is a promising but presently innovative and unvalidated technology for promoting the degradation of EDB to nontoxic products. The efforts described herein are primarily designed to evaluate the extent to which potential treatment amendments for in situ biostimulation and bioaugmentation enhance anaerobic EDB biodegradation processes.

Efforts described in this Work Plan related to changes in the carbon isotope composition of EDB during degradation are funded separately by the U.S. Department of Defense (DoD) Environmental Security Technology Certification Program (ESTCP) research project ER-201331. The ESTCP research program was established in 1995 to promote the transfer of innovative technologies, including remediation technologies, from proof-of-concept to practical application, and the ongoing ESTCP project is entitled, “Natural Attenuation and Biostimulation for In Situ Treatment of 1,2-Dibromoethane (EDB).” While ESTCP project ER-201331 includes efforts examining natural attenuation of EDB, the primary objective of the work described herein is to demonstrate ISB of EDB under anaerobic conditions, and to test the innovative technology of compound specific isotope analysis (CSIA) to observe changes in the carbon isotope composition of EDB during this biodegradation process.

Anaerobic bioremediation for halogenated compounds often involves stimulating biodegradation activity in situ through the addition of electron donors (e.g., lactate, vegetable oil), nutrients, and a bioaugmentation culture, as necessary. For EDB, bioaugmentation could use mixed anaerobic cultures that contain Dehalococcoides spp., or other strains that can reductively debrominate EDB. The application of enhanced anaerobic bioremediation for EDB is supported by laboratory studies that have shown that EDB is biodegradable under such conditions (Belay and Daniels, 1987; Bouwer and McCarty, 1985; Henderson et al., 2008; Peethambaram, 2010; Yu et al., 2013).

Recent analyses of the groundwater microbial community at Kirtland AFB using Microbial Insight’s QuantArray-Chlor protocol indicated that microorganisms that dehalogenate EDB, or its chlorinated analog 1,2-dichloroethane (1,2-DCA), are present in the subsurface (Figure 1). Additionally, treatability testing using Kirtland AFB soil and groundwater showed that bioaugmentation with a known dehalogenating culture (SDC-9) significantly enhanced EDB degradation rates (Figure 2). These results indicate that ISB, by stimulating the activity of indigenous EDB-degrading organisms (i.e., biostimulation) or bioaugmenting with a dehalogenating culture (e.g., SDC-9), shows promise for enhancing EDB degradation at Kirtland AFB.
Figure 1. Population Densities of Specific Dehalogenating Organisms in a Transect Across the Kirtland AFB BFF Site

Wells sampled for microbial community analysis are provided on the map above. The organisms shown in the graphs at the bottom of the figure are reasonably anticipated to degrade halogenated ethanes such as EDB or 1,2-DCA. The numbers provided are geometric averages over three or four quarters of sampling in cells per milliliter of groundwater. The data show relatively low concentrations of *Dehalococcoides* spp. at the site, but larger populations of the three other dehalogenating species are present.
The treatments that were amended with the dehalogenating culture SDC-9 showed increased degradation of EDB.

2.0 PILOT TEST OBJECTIVES

The primary objective of this pilot test is to evaluate the extent to which potential treatment amendments for in situ biostimulation and bioaugmentation enhance anaerobic EDB biodegradation processes. Evaluation of the test will be completed through a comprehensive groundwater sampling regimen that assesses direct and indirect indicators of EDB biodegradation. This pilot test is primarily designed to inform whether the proposed amendments can stimulate enhanced anaerobic EDB biodegradation. Information regarding the distribution of amendments in the subsurface will be collected primarily to aid interpretation of biodegradation effectiveness, but may provide some insight into how similar systems may be scaled up for larger scale bioremediation treatments.

The design of the pilot test system and monitoring program are discussed in more detail in the following sections.
3.0 PILOT TEST

Details related to the pilot test are described in the following subsections.

- In situ biodegradation pilot test location
- Installation of the injection/extraction/monitoring wells necessary for the in situ biodegradation test
- Installation of pilot test equipment
- Operations during the four phases of the pilot test, including groundwater sampling
- Data analysis and reporting of testing results

3.1 Test Location

The pilot test will be performed near the EDB contaminant source at the location identified on Figure 3. Shallow and intermediate EDB plume contours in the source area and surrounding area from Q4, 2015 have been included as Figure 4. The treatment test area will include groundwater injection, extraction, and monitoring wells near the existing monitoring well cluster that includes Kirtland AFB (KAFB)-106062, KAFB-106063, and KAFB-106064, approximately 300 feet to the east of Building 1024. The water table at the test location occurs at approximately 480 feet below ground surface (bgs), and the newly installed pilot test groundwater wells will be screened in the shallow part of the aquifer within the Santa Fe Group. Site knowledge, from previous wells drilled in this area, suggests inter-bedded sands and gravels with occasional finer layers at this depth that are is anticipated to be adequately water conductive. Well screens will be placed to target the highest EDB concentrations (i.e., approximately the top 20 feet of the aquifer), and groundwater extraction and injection will primarily facilitate flow in the soil materials of greatest hydraulic conductivity. Due to the nature of the active amendment delivery system and proposed screen length, thinner lithological layers of lower hydraulic conductivity (e.g., less than 5 feet) are not anticipated to affect the performance of the pilot test. However, professional judgment will be exercised in the field and screen placement may be reasonably adjusted several feet due to the presence of such features, if observed. If clay or other fine-grained layers of significant thickness are encountered during drilling that are anticipated to affect the performance of the technology, CB&I will communicate with AFCEC, USACE, and NMED on a path forward. Draft borehole logs will also be provided to NMED on a daily basis during drilling.

The background gradient at the site is small and pumping of wells and reinjection during pilot test operations will induce a large gradient exceeding that of the background. Based on recent data, the groundwater gradient in the pilot test area is less than 0.002 foot/foot (Quarter 1 [Q1] 2016), and the direction of groundwater flow has possibly shifted from north-northeast to a more east-southeast direction, likely due to continuing water-conservation practices by the Albuquerque community and reduction of pumping of production wells by Albuquerque Bernalillo County Water Utility Authority. Preliminary modeling suggests that the induced gradient during operation of the pilot system will be on the order of 0.02 foot/foot, or approximately an order of magnitude greater than current gradients in the test area. As such, the pilot test is anticipated to be fairly insensitive to current groundwater flow direction.

The pilot test wells, which include KAFB-106063, KAFB-106064, and the seven new wells to be installed, are shown on Figure 3. The pilot test will consist of one injection, two extraction, and six monitoring wells, including existing monitoring wells KAFB-106064 and KAFB-106063 (nine wells total). Well KAFB-106IN1 will be used as an injection well for recirculated groundwater and amendment injection; wells KAFB-106EX1 and KAFB-106EX2 will be used as groundwater extraction wells; and existing wells KAFB-106064 and KAFB-106063, and new wells KAFB-106MW1-S, KAFB-106MW1-I, KAFB-106MW2-S, and KAFB-106MW2-I will be used as monitoring wells.
Figure 3. Pilot Test Plot Well Layout
Figure 4. EDB Concentrations Contours in Groundwater at Kirtland AFB
Proposed wells were sited to accommodate existing well infrastructure, sites utilities, and to facilitate use of existing wells for monitoring. The two extraction wells will be located approximately 90 feet from the single injection well as shown in Figure 3. The extraction wells will be used to periodically recirculate groundwater during individual phases of the pilot test. During extraction and injection, both extraction wells will be effectively downgradient of the injection well, as the induced gradients should greatly exceed the background gradient. The periods of active groundwater extraction and reinjection will be used to facilitate the distribution of amendments at the test location. After sufficient amendment distribution, pumping will be halted and treatment performance will continue to be monitored. Monitoring wells installed as identified on Figure 3 will be the primary locations used to observe ISB performance.

The anticipated screen intervals of the wells are presented in Table 1. Existing wells KAFB-106063 (screened from 505 to 520 feet bgs, with top of screen approximately 25 feet below the current water table) and KAFB-106064 (screened from 485 to 505 feet bgs, with top of screen approximately 5 feet below the current water table) will be used for monitoring along with four proposed monitoring wells. The design and locations of the new wells were selected to evaluate EDB biodegradation and are based upon current knowledge of dissolved EDB distribution, as determined during previous characterization activities. The four new monitoring wells will be installed within two boreholes utilizing a nested design with two wells in each borehole. Each borehole will contain a shallow well with 15 feet of screen in the vadose zone and approximately 20 feet of screen in the aquifer and a slightly deeper well with top of screen set approximately 35 feet below the current water table. Well screen intervals will be isolated within the borehole using bentonite seals. A conceptual nested well design for the proposed monitoring wells is included in Appendix A.

Table 1. Anticipated Screen Intervals for Monitoring, Injection, and Extraction Wells

<table>
<thead>
<tr>
<th>Well Location ID</th>
<th>Well Status</th>
<th>Well Use</th>
<th>Well Screen Interval (feet bgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KAFB-106064</td>
<td>Existing</td>
<td>Monitoring</td>
<td>485-505</td>
</tr>
<tr>
<td>KAFB-106063</td>
<td>Existing</td>
<td>Monitoring</td>
<td>505-520</td>
</tr>
<tr>
<td>KAFB-106MW1-S</td>
<td>New</td>
<td>Monitoring</td>
<td>465-500</td>
</tr>
<tr>
<td>KAFB-106MW1-I</td>
<td>New</td>
<td>Monitoring</td>
<td>515-525</td>
</tr>
<tr>
<td>KAFB-106MW2-S</td>
<td>New</td>
<td>Monitoring</td>
<td>465-500</td>
</tr>
<tr>
<td>KAFB-106MW2-I</td>
<td>New</td>
<td>Monitoring</td>
<td>515-525</td>
</tr>
<tr>
<td>KAFB-106IN1</td>
<td>New</td>
<td>Injection</td>
<td>480-500</td>
</tr>
<tr>
<td>KAFB-106EX1</td>
<td>New</td>
<td>Extraction</td>
<td>490-505</td>
</tr>
<tr>
<td>KAFB-106EX2</td>
<td>New</td>
<td>Extraction</td>
<td>490-505</td>
</tr>
</tbody>
</table>

* Assumes a static water table at 480 feet below ground surface.

ID identification
bgs below ground surface

A 35-foot screen will be installed in both of the proposed shallower monitoring wells (KAFB-106MW1-S and KAFB-106MW2-S). These screens will extend 15 feet up into the current vadose zone to accommodate continued groundwater rise in the area, and facilitate detection of light non-aqueous phase liquid (LNAPL) during sampling (see Section 2.2). The proposed deeper monitoring wells (KAFB-106MW1-I and KAFB-106MW2-I) will have a 10 foot screen set from approximately 35 to 45 feet below the current water table.

The top of the extraction well screens will be placed 10 feet below the water table to minimize aeration of extracted water during pumping. All well screens will be placed in what is expected to be a highly water conductive zone (based on previous wells in the area), and small scale lithological features are not expected to drive screen placement. However, professional judgment will be used during drilling and well screens can be adjusted by several feet to account for lower hydraulic conductivity lithological layers, if encountered. Additionally, modifications to the well depths will be made, as needed, based upon measured groundwater depth during well installation activities.
The pilot system, distance between wells, and well depth are based on current site characteristics. The characteristics that drove the design of the test include 1) the vertical and lateral distribution of EDB in this area, 2) the currently existing infrastructure that drives the distance between wells (i.e. existing wells and utilities), 3) the existing flat natural gradient, and 4) general knowledge of the site geology at this depth. This information was used to inform injection/extraction rates and anticipated time to recirculation connectivity between all wells. Key aspects that serve as the design basis and rationale for the selected location are discussed in more detail below:

- **Pilot Testing Centered Within Elevated EDB Concentration Zone (concentrations greater than 5 micrograms per liter)**—Historic groundwater sampling has shown elevated EDB concentrations within the footprint of the pilot test plot (See Figure 4), and within the target depth interval of approximately the top 20 feet of the water column. Greater EDB concentrations facilitate the demonstration of ISB of EDB. Concentrations of EDB at deeper intervals (i.e., waters below the top 20 feet of the water column) are too low to reasonably evaluate the performance of EDB ISB.

- **Anaerobic Groundwater**—Anaerobic conditions necessary for the planned ISB are present at the test location. The pilot test is not expected to adversely impact the aquifer geochemistry or mineralogy. Anaerobic conditions minimize the risk of iron and manganese oxide mineral formation that might affect hydraulic performance of the aquifer. Anaerobic conditions should also lower the consumption of fermentable substrate during the biostimulation and bioaugmentation phases of the pilot test.

- **Microbial Community**—QuantArray-Chlor analyses of the microbial community indicated that microorganisms that dehalogenate EDB, or its chlorinated analog 1,2-DCA, are present in the subsurface in the pilot test area. The biostimulation phase of the pilot test will attempt to stimulate these organisms for ISB.

- **Site Infrastructure**—There are no buildings or other infrastructure in the pilot test area that would be expected to preclude implementation of the pilot test.

- **Groundwater Flow Direction Between Injection and Extraction Wells**—Ambient groundwater flow is currently slow and in a general east-to-southeast direction within the pilot test area. While injection/extraction wells have been oriented to be in line with expected flow conditions, the pilot system is expected to operate independent of ambient groundwater flow. Similarly, monitoring wells will be located near the injection well and should effectively sample the pilot test zone independent of ambient groundwater flow.

- **Well Capacity**—Based on site experience, groundwater wells located in the pilot test area are expected to be capable of producing at least 12 gallons per minute (gpm) of groundwater.

- **Amendment Distribution**—Groundwater modeling was used to verify that well designs and pumping rates are expected to sufficiently distribute amendments during the pilot test. Based on this groundwater modeling, pumping extraction wells KAFB-106EX1 and KAFB-106EX2 at approximately 12 gpm each (24 gpm total) and reinjecting into injection well KAFB-106IN1 will allow sufficient amendment distribution. Figure 5 shows the modeled horizontal distribution of a conservative tracer after approximately 30 days of recirculation at 24 gpm, which indicates that amendments will likely be distributed within the pilot test zone and associated wells. Monitoring wells surrounding the injection well at distances of approximately 35 feet and extraction wells at distances of approximately 90 feet from the injection well will be evaluated for amendment and tracer distribution and evidence of EDB degradation. Additionally, the injection well will be evaluated for amendment distribution and EDB loss during the periods when it is not used for injection.
Figure 5. Modeled Distribution (Percent of Injection Concentration)
3.1.1 Permitting

Prior to the start of this pilot test, all applicable notifications will be delivered and permits will be acquired including NMED Groundwater Quality Bureau NOI, Office of the State Engineer (OSE) drill and install permits for all wells, OSE change of water rights permit, and Albuquerque Environmental Health Department fugitive dust permit. Kirtland AFB utility clearance permit and civil engineer work permit have also been acquired to construct the system and use the pilot test area.

3.2 Well Installation

The installation of the seven new wells listed in Table 1 (locations presented on Figure 3) will be accomplished as the first task under this Work Plan by using air rotary casing hammer drilling methods. Well-installation activities will include drilling, geologic logging, well material installation, development, pump installation, and associated tasks for the proposed wells. The two proposed shallower monitoring wells will be installed with the top of screen 15 feet above the static groundwater level and will extend to 20 feet below static level (groundwater is approximately 480 feet bgs at adjacent well locations). The two proposed intermediate monitoring wells will be installed with the top of screen set approximately 35 feet below the static water level. The four proposed monitoring wells will be installed in two boreholes with each borehole containing two wells (one shallow, one intermediate); screened intervals will be separated by bentonite seals to effectively isolate the screens within the borehole. A conceptual well design is included in Appendix A.

The injection well will be installed with the top of screen at the static groundwater level and will extend to 20 feet below static water level. To minimize aeration of extracted water, extraction wells will be installed such that the entireties of their screens remain below the anticipated water level during pumping conditions. The shallow monitoring and injection wells are anticipated to be completed to a depth of approximately 500 feet bgs, the intermediate monitoring wells are expected to be completed to a depth of approximately 525 feet bgs, and extraction wells are anticipated to be completed to a depth of approximately 510 feet bgs, although adjustments may be made in the field during installation depending on the observed depth to the static water table and lithology encountered during drilling.

LNAPL is not expected in the area of the pilot test, as LNAPL has not been measured (or determined by sheen) in groundwater monitoring wells in the test area or immediately upgradient since Q4 2011. It is also noted that LNAPL was not observed at wells in this area prior to the submergence of the top of screen at KAFB-106064 (a total of 12 quarterly measurements between Q1 2012 and Q4 2014; screen was submerged by Q1 2015). However, newly installed wells will be monitored for presence of LNAPL several days after installation. If LNAPL is observed during well monitoring, a conference call will be initiated among USACE, CB&I, USAF, and the New Mexico Environment Department (NMED) to discuss whether the project should move forward at the planned location. The two new monitoring wells will be screened partially above the current water table in order to detect any LNAPL that is present over the course of the study.

3.2.1 Utility Clearance Prior to Drilling and Trenching

Utility clearances will be conducted to locate all underground and overhead utilities in the work area. Utility clearances will be conducted in accordance with the procedures outlined in Section 4.2.1 of the Groundwater Investigation Work Plan (USACE, 2011).

Restoration of the site surface will be done in accordance with Section 3.2.6.6 to restore the pilot test area to natural conditions.
3.2.2 Geologic Logging

New wells will be logged in accordance with the Unified Soil Classification System and ASTM International D1586-84 and Section 4.2.3.1 of the Groundwater Investigation Work Plan (USACE, 2011) by a degreed geologist. A professional geologist will review the well logs prior to submittal to the Office of the State Engineer.

3.2.3 Survey Requirements

The surveying of wells and other system features will be conducted using the North American Datum of 1983 New Mexico State Plane coordinate system and the North American Vertical Datum of 1988 vertical datum. Land-surveying activities will be conducted in accordance with the United States Geological Survey Standard Operating Procedure developed for all monitoring wells on Kirtland AFB (USGS, 2016), with the following additions:

- Any additional measuring points or piping on the extraction and injection wells will be surveyed if determined necessary.

3.2.4 Waste Management

All wastes generated during installation of the wells will be handled and disposed of as described in Section 2.4.4.

3.2.5 Pilot Test Groundwater Monitoring Wells

Pilot test groundwater monitoring wells will be installed and developed as described in the following sections. The shallow wells (KAFB-106MW1-S and KAFB-106MW2-S) will include a drop pipe for collection of manual water level measurements (and to assess the presence or absence of LNAPL) prior to sampling events.

3.2.5.1 Well Construction

The proposed pilot test monitoring wells are located near an existing monitoring well cluster. Both of the proposed shallow monitoring wells will be installed with 15 feet of screen extending up into the vadose zone, which can facilitate future monitoring and characterization activities after the completion of this pilot test, while accounting for the anticipated continuance of water table rise in the area. The proposed intermediate wells in each of the nested boreholes will have the top of screen set at approximately 35 feet below the static water table. A conceptual well design for the new monitoring wells is included in Appendix A.

Additionally, drill cuttings from just above and in the saturated zone will be screened for presence of LNAPL and VOCs using a photo ionization detector to collect headspace measurements. Drill cuttings will also be carefully visually inspected.

The following proposed well design parameters apply to the new groundwater monitoring wells:

- The wells will be constructed within a 11¾ -inch lower diameter, 13 3/8-inch diameter upper diameter) borehole using a 2.5-foot Schedule 80 polyvinylchloride (PVC) sump and flush-threaded cap on the shallow wells and a 5-foot sump on the intermediate wells; Schedule 80 PVC screen with 0.020-inch slots; and 4-inch Schedule 80 PVC riser pipe to the top of the well into the well vault for the shallow well and 3-inch Schedule 80 PVC riser pipe on the intermediate well.
• KAFB-106MW1-S and KAFB-106MW2-S will be installed with a 35-foot screen, with the top of screen at 15 feet above the static groundwater level and extending to 20 feet below static water level.

• KAFB-106MW1-I and KAFB-106MW2-I will be installed with a 10-foot screen, with the top of screen set at approximately 35 feet below static water level.

• For KAFB-106MW1-I and KAFB-106MW2-I, 16/30 Colorado silica sand (CSS) filter pack will be placed from the bottom of the borehole to approximately 5 feet above the top of the screen.

• Five feet of TR-60 Hole Plug (or equivalent) will be placed above the filter pack of the intermediate screen interval to isolate the well screen from the shallow well screen to be placed above.

• For KAFB-106MW1-S and KAFB-106MW2-S, 16/30 Colorado silica sand (CSS) filter pack will be placed from the top of the bentonite seal to 5 feet above the top of the shallow screen.

• Five feet of TR-60 Hole Plug will be placed above the filter pack of the shallow screen interval to seal the borehole and prevent intrusion of the bentonite grout above.

• High solids bentonite grout will be placed above the top hole plug seal to approximately 5 feet bgs.

3.2.5.2 Well Development

Groundwater monitoring well development will follow the procedures outlined in Section 4.2.4.3 of the Groundwater Investigation Work Plan (USACE, 2011).

3.2.5.3 Pump Installation

Dedicated pneumatic bladder sampling pumps will be installed in each of the six groundwater monitoring wells being used for the pilot test (KAFB-106064, KAFB-106063, KAFB-106MW1-S, KAFB-106MW1-I, KAFB-106MW2-S, KAFB-106MW2-I) following development of the four new monitoring wells. The pumps will be hung on a poly-coated stainless steel hanging wire such that the pump intake area is set at approximately the middle point of the saturated screen interval. The top of the pump bundle will include a single cap with access to the discharge line, hanging cable, and air-line. This hanging cap will fit securely into the top of the sanitary well seal.

3.2.5.4 Surface Completion

Surface completion for new groundwater monitoring wells will be installed as flush mounts in accordance with Section 4.2.4.1 of the Groundwater Investigation Work Plan (USACE, 2011).

3.2.6 Extraction and Injection Wells

Extraction and injection wells will be installed and developed as described in the following sections. Conceptual construction diagrams for both types of wells have been included in Appendix A.

3.2.6.1 Well Construction

Extraction and injection wells will be designed and constructed in accordance with the procedures outlined in the Groundwater Extraction Pilot Implementation and Additional Plume Characterization Letter Work Plan Addendum #3 (USACE, 2015b). To minimize aeration of extracted water, the two extraction wells will be installed with 15-foot screens, the top of which will be located 10 feet below the static groundwater level. Amended groundwater will be injected at approximately the mid-point of the
20-foot injection well screen interval. As the extraction and injection wells are being used as part of the pilot testing, which is targeting a shorter screen interval than similar wells of this type installed previously at the site, and extracting and injecting water at much lower flow rates than the previous work, some changes in well construction are appropriate. All extraction and injection wells will have a transducer installed for the monitoring of water levels during and after periods of recirculation (integrated for use in system control). The following apply to the design of both the extraction and injection wells:

- Both the extraction and injection wells will be drilled using air rotary casing hammer drilling technology.
- The wells will be constructed within a telescoping (11¾ -inch lower diameter, 13 3/8-inch upper diameter) borehole using a 5-foot standard dimension ratio 17 PVC sump and flush-threaded cap; 304 stainless steel wire wrap screen with a 0.040-inch slot; and 6-inch standard dimension ratio 17 PVC riser pipe.
- The 20-foot screen of the injection well will be installed with the top of screen at the static groundwater level and will extend to 20 feet below the static water level.
- The 15-foot screen of the two extraction wells will be installed with the top of screen 10 feet below the static groundwater level and will extend to 25 feet below the static water level.
- 10/20 CSS filter pack will be placed from the bottom of the borehole to 10 feet above the top of screen.
- A 10-foot hydrated bentonite seal using ¾-inch bentonite chips will be placed above the sand filter pack, and will be incrementally hydrated in 1-foot lifts using potable water or other suitable water, such as treated water from the full-scale EDB groundwater treatment system (GWTS).

3.2.6.2 Well Development

Well development of the extraction and injection wells will follow procedures similar to those outlined in the Groundwater Extraction Pilot Implementation and Additional Plume Characterization Letter Work Plan Addendum #3 (USACE, 2015b) and Addendum #4 (USACE, 2015c). However, as these extraction and injection wells are being used as part of the pilot testing, which is targeting the top 20 feet of the water column only and extracting and injecting water at much lower flow rates than the previous work, the following specific steps will be followed:

- **Step 1, Initial Development**—This step will consist of swabbing, bailing, and pumping until little or no sediment enters the well. There are two purposes for this step: 1) to remove sediment, any construction debris, and natural drilling fines that may have accumulated, so that only sediment-free water will remain for subsequent development steps, and 2) to estimate initial specific capacity. This step will include initial bailing, followed by gentle surging and bailing, and finally constant pumping. During the pumping stage, discharged water will be monitored for sediment content using an Imhoff cone.

- **Step 2, Mechanical Pumping and Surging**—The wells be pumped and surged in iterative cycles of 7 minutes pumping and 7 minutes surging, using at least 4 cycles per hour. Surging will be conducted by stopping the pump (no internal check valve installed), opening the top of the water column and allowing the 500 feet of water in the discharge pipe to flow back down into the well, reversing flow across the screen. After 4 cycles, or approximately 1 hour, the well will be pumped for 20 minutes at a constant rate. The iterative cycles will be repeated to reach a goal of no less than 2 gallons per minute per foot (gpm/ft) of drawdown.
When the specific capacity has been achieved, groundwater will be allowed to recover to static or near static levels, and the well will be pumped at a constant rate for 180 minutes to verify the estimated specific capacity. If the goal is not met at the end of this constant rate test, then additional development activities, such as hydraulic surging or jetting, will be considered. It is anticipated that operation of the recirculation system will provide head measurements and tracer data that can be used to evaluate hydraulic conductivities in this area.

3.2.6.3 Extraction Well Pump Installation

Extraction pumps will be multi-stage centrifugal pumps. The pumps will be attached to approximately 500 feet of 1.5-inch threaded steel pipe, which will be attached to a sanitary well seal at the top of the well casing. Pumps will be set so the intake is no more than 5 feet above the bottom of the screen to allow sufficient room for drawdown during pumping. The groundwater model used for verification of design, determined the anticipated drawdown due to pumping would be 1-2 feet and mounding at the injection well approximately 2-3 feet.

Corrosion of pump and piping materials will be minimized primarily through use of corrosion resistant materials; but a sacrificial zinc anode will be installed on the drop pipe for further protection.

3.2.6.4 Injection Well Installation

Groundwater injection will require the installation of a sanitary well seal and 1.5-inch-diameter threaded steel pipe in the well casing to convey water from the piping exiting the Conex box to the screened interval of the injection well. The injection pipe will extend down into the water column, ending at approximately the mid-point of the screen interval. The pipe will be fitted with a 4-inch diameter custom-built Baski down-hole flow-control valve (FCV) to limit risks of cavitation within the pipe, and to minimize volatilization and aeration of the anaerobic recirculation water. A check valve will be installed at the base of the FCV, and an electric submersible pump with variable speed frequency drive will be installed underneath to sample groundwater in the vicinity of the injection well (when the recirculation system is off and water is not being injected). Corrosion of the FCV, pump, and pipe materials will be minimized primarily through use of corrosion resistant materials, and the use of sacrificial zinc anodes.

3.2.6.5 Surface Completion

Extraction and injection well vaults will be installed to house the wellhead and any plumbing, fittings, and remote instrumentation necessary for operation and monitoring. Due to the location of the pilot test area being in an open field, traffic-rated vaults will not be required. Additional design details for the wellheads and vaults are included in Appendix A.

3.2.6.6 Trenching for Pipeline

Utilities connecting the Conex box to the extraction and injection wells will be installed in trenches approximately 4 feet deep (below the frost line). The trenches will accommodate the water piping, injection valve pneumatic tubing, pump electrical leads, well vault leak detection wire, and water-level transducer wire leading from the Conex box to the wells. The test is located in an area of currently undeveloped land containing natural surface and native vegetation. After trenching and laying utilities, trenches will be backfilled with the onsite excavated native soil and shaped to match the natural elevation and conditions. Reseeding with native plants will be performed to restore the surface.

3.3 Pilot Test Equipment and Materials

The pilot test involves multiple test phases requiring recirculation of anaerobic groundwater and addition of tracers and amendments to this water. These phases are described further in Section 3.4.1. The
equipment necessary to perform the pilot test will be installed in the appropriate wells and a portable shipping (Conex-type) container, and will include necessary pumps, filters, mixers, meters, electrical, and piping to add tracers/amendments and distribute them in the subsurface (as detailed in this section). The container will also be used for security and environmental control and will be located adjacent to the well field test area, see Figure 6. System components that may be exposed to high-vapor concentrations of hydrocarbons from the subsurface will be intrinsically safe and isolated from other components and equipment. The system will be designed by CB&I, together with subcontractors, and will be fabricated by a CB&I-approved subcontractor. CB&I and the subcontractor will perform all necessary system installation, shake-down verification testing (including, but not limited to, pressure testing and alarm functionality testing), and start-up tasks. The final design of the system and associated as-builts will be included in the Final Report after the pilot test is complete.

The main components of the recirculation system are identified on a process flow diagram presented as Figure 7. To maintain anaerobic conditions of the groundwater and aquifer and to prevent the loss of volatile components within the groundwater, the system is designed to minimize gas exchange between the recirculated groundwater and the atmosphere. The system will extract groundwater from the two extraction well locations and reinject that groundwater in the injection well after the tracer or amendment addition at an anticipated flow rate of 24 gpm. This flow rate is expected to be achievable based on the design of the wells and knowledge of site conditions and has been validated with the groundwater model (see Figure 5), but may be altered up or down based on observed injection and extraction flow rates and water levels in the field, or to optimize the recirculation system performance based on tracer results. This flow rate will also be evaluated as part of the initial tracer test.

Electrical power requirements for system operation will be supplied by on-base grid power, by running an electrical line from the power source on the east side of the site to the test area (see Figure 6). 480-volt, 3-phase, 60 Hz. power will be required to operate the extraction well pump motors. CB&I is working with base civil engineering personnel and a licensed electrical subcontractor to procure and install the necessary transformer and service to the Conex system location. Trenching of the main power supply cable to the Conex box will be required. Appropriate dig and base civil engineer permits have already been acquired prior to starting work and trenching and site restoration will be completed in accordance with Section 3.2.6.6.

Draft electrical and design drawings for the system and for the site electrical service have been included in Appendix A.

The treatment system will include a supervisory control and data acquisition (SCADA) system for remote monitoring of flow rates and other parameters, though on-site adjustments and maintenance will be necessary. Piping and control wiring running between the Conex box and the extraction/injection wells will be installed in below-grade trenches, as discussed in Section 3.2.6.6. Process instrumentation, including pressure, level, and flow gauges/switches, will be installed at critical locations in the system to ensure safe and controlled operation. A working piping and instrumentation diagram is provided for reference in Appendix A. The programmable SCADA and logic controllers will contain all the process control logic to monitor and regulate the operation of the various system components, both locally and remotely. The SCADA will enable the application of power to the pumps, monitor the system safety interlocks, and call out when the system is offline.
Figure 6. Site Map With Utility Locations, Proposed Trenches, and System

Legend
- Monitoring Well
- Pilot Test Monitoring Well
- Pilot Test Injection/Extraction Well
- Wall Line
- Natural Gas Line
- Wastewater Line
- Water Line
- Electrical Cable Line
- Construction Fence Area
- Truck Exit Route
- Pilot Test Trench Location for Water Pipe and Subsurface Electrical
- Pilot Test System Location
- Pilot Test Existing Electrical Tie-in
- Proposed Electrical Service Line

SITE LOCATION

Revision Date: 10/13/16

1 inch = 60 feet

FIGURE 6

SITE LOCATION MAP
Figure 7. Process Flow Diagram
System callouts will occur when the system is offline due to a safety interlock. The following alarms will be included:

- High recirculation system pressure
- No/low recirculation system flow
- Extraction and injection well water levels
- Low tracer/amendment solution liquid level
- System enclosure floor and well vault water sensor detection

Groundwater extraction will occur through the use of electric submersible well pumps (Grundfos 25S50-26, or equivalent) with variable speed frequency drives. Each of the two 4-inch-diameter pumps will be fully submersible and capable of maintaining design flows. The variable speed frequency drive will be controlled by input values from the SCADA system to fine tune motor operation to adjust flow rates, as needed. Once groundwater is extracted from the wells, the groundwater will be directed through particle filters prior to combining flows. These filters are used to prevent undesired particulates from entering the amendment and reinjection portions of the system. Pressure switches will be installed on the upstream side of the particle filters (as shown on the P&ID presented in Appendix A), to sense an increase in back pressure on the filters, which is evidence of particle build-up. The SCADA system will have two alarm set-points associated with these pressure switches. The first (high pressure alarm) will just be an indicator to the system operator that the filters are in need of cleaning/changing, while the second (high-high pressure alarm) will shut-down the system until the filters are cleaned/changed and the system is manually restarted.

Prior to the injection well, groundwater will be mixed with either tracer or amendments (depending on the phase of operation, as discussed in Section 3.4.1) using a tracer and amendment delivery system consisting of a nutrient reservoir, control valves, pressure gauges, positive displacement variable speed metering pumps, and a mixing tank. The reservoir will likely be a minimum of 500 gallons, the mixing tank will be designed to maintain anaerobic conditions, and the metering pumps will be able to average flows necessary to meet recirculation process stream amendment concentration goals (as will be discussed on Section 3.4.1 below). All tracers and amendments proposed for this study are industry standard chemicals in common use for similar treatments. Safety Data Sheets (SDSs) for the proposed tracers and amendments have been included as Appendix B of this Work Plan.

A down-hole FCV and submersible pump, both installed in the injection well, will also be controlled by input values from the SCADA system, as needed. The system will shut-down automatically if the water level transducer in the injection well indicates that the water level in the well casing has risen to approximately 10 feet above the static level, or if the water level transducer in one or both of the extraction wells indicates that the water level has dropped to within approximately 2 feet of the top of the extraction well screen.

At the conclusion of the pilot test, the wells will be left in place, and the Conex box and pilot test system (considered Government property) will remain on Kirtland AFB for potential future use by the USAF or its contractors for site remediation or further remedial testing.
3.4 System Operations

The pilot testing will be performed in four phases. The duration of each of the main pilot testing tasks is summarized in Table 2. It should be noted that data will be evaluated during each phase of pilot testing, and the durations provided in Table 2 are preliminary and may be modified pending results observed in the field. The first phase will start immediately after installation, development, and testing of the wells and equipment associated with the pilot test system. The first phase will include an evaluation of baseline conditions, and operation of the recirculation system while performing a tracer test to evaluate distribution of injected water in the subsurface. The second phase will include an evaluation of biostimulation on EDB degradation through operation of the recirculation system and the addition of nutrients and a fermentable substrate to the subsurface. The third phase of the pilot testing will involve the implementation of bioaugmentation treatment, and an evaluation of enhanced EDB degradation. The fourth and final phase of the pilot testing will be post-treatment monitoring and assessment. Activities during this final phase will focus on longer term performance of the pilot test.

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Approximate Duration of Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Installation</td>
<td>2 months</td>
</tr>
<tr>
<td>System Fabrication</td>
<td>2-3 months</td>
</tr>
<tr>
<td>System Installation</td>
<td>1-2 months</td>
</tr>
<tr>
<td>Phase 1 System Operation</td>
<td>2-3 months (dependent on testing data)</td>
</tr>
<tr>
<td>Phase 2 System Operation</td>
<td>4-5 months (dependent on testing data)</td>
</tr>
<tr>
<td>Phase 3 System Operation</td>
<td>4-5 months (dependent on testing data)</td>
</tr>
<tr>
<td>Phase 4 System Operation</td>
<td>6 months</td>
</tr>
<tr>
<td>Reporting</td>
<td>2 months (Q1 2017), 1 month (Q2 2017), 2 months (Q1 2018)</td>
</tr>
</tbody>
</table>

3.4.1 Pilot Test Phases

Each phase of the pilot test contributes new and valuable information regarding the performance of EDB ISB and will be implemented unless baseline metrics prior to each phase (e.g., EDB concentration) are such that no degradation information can be expected. One example of this could be non-detectable EDB concentrations that preclude observation of additional EDB degradation. More detailed descriptions of the pilot test phases are included below, followed by a summary of the sampling that will be performed.

3.4.1.1 Evaluation of Baseline Conditions and Conservative Tracer Testing – Phase 1

All pilot test wells will be sampled prior to recirculation activities to establish pre-test baseline conditions. Groundwater (without biostimulation or bioaugmentation amendments) will then be recirculated at an anticipated flow rate of 24 gpm for 1 month. This effort will distribute injected water throughout the pilot testing zone and allow for new experimental baseline measurements that will be compared to later biostimulation and bioaugmentation phases. During Phase 1, two conservative (i.e., non-reactive) tracers of water flow will be used to evaluate subsurface transport and amendment distribution characteristics. Bromide or chloride will not be used as tracers because ratios of these anions may be useful to help assess EDB degradation. The two tracers to be used are fluorescein and water labeled with additional deuterium (²H), a stable isotope (i.e., non-radioactive) of hydrogen. The tracer test will use a pulse of approximately 15 kilograms of deuterium oxide (²H₂O) over a period of approximately 24 hours near the start of recirculation activities. The addition of ²H₂O will increase the deuterium composition of approximately 35,000 gallons of recirculated water by 66% and raise its δ²H value by approximately +660 ‰. A 24-hour pulse of fluorescein (with the injection concentration dependent on analysis of background fluorescence in site groundwater collected during baseline sampling) will also be
used to verify results from the $^2\text{H}_2\text{O}$ tracer, as well as to verify the suitability of fluorescein as a conservative groundwater tracer under site conditions for use during Phase 3.

Eight groundwater sampling events designed to quantify transport properties during active recirculation are anticipated with two additional sampling events to be conducted approximately 2 and 4 weeks after recirculation activities have ceased. Groundwater fluorescein concentrations and $\delta^{2}\text{H}$ values will be determined for these samples. Additional groundwater will also be collected during a subset of these sampling events to determine baseline conditions for the other analytes as described in Section 2.4.3. All Phase 1 sample collections are expected to be complete 1 month after the cessation of active recirculation.

### 3.4.1.2 Evaluation of Biostimulation – Phase 2

Phase 2 consists of two periods, a recirculation/mixing period, and a subsequent passive monitoring period. During the approximately 1-month recirculation period, groundwater will be extracted and an easily fermentable sodium lactate-based substrate (e.g., WilClear Plus, manufactured by JRW Bioremediation), nutrient (diammonium phosphate [DAP]), and conservative tracer (iodide) will be added to the recirculated process water stream. The amended water will be re-injected to distribute the amendments throughout the pilot testing zone. The goal of these amendments is to stimulate activity of native microbial populations capable of dehalogenating EDB. A concentrated solution of these amendments will be prepared in a feed tank and added to the process stream by the chemical feed pump, so that average injection concentrations (amendment feed mixed with recirculated groundwater) of approximately 300 milligrams per liter (mg/L) lactate, 100 mg/L DAP, and 20 mg/L iodide are attained. Over the anticipated 1-month injection period, approximately 3,000 pounds (lbs) of lactate, 1,000 lbs of DAP, and 200 lbs of iodide will be injected. If pH values decrease below 5.5, a dilute sodium carbonate solution will be added to neutralize pH. A pulsed amendment injection scenario will be implemented to minimize any potential biofouling in the injection well. It is anticipated that the amendments will be delivered for 80 minutes during a two-hour cycle; thus, 80 minutes of amendment delivery into the recirculation process stream followed by 40 minutes of groundwater recirculation only. This cycle timing equates to an amendment delivery flowrate of approximately 1.75 gallons per hour (assuming the recirculation process stream is flowing at 24 gpm). Approximately 830 gallons of amendment will be required during the estimated 1-month recirculation period. The amendment delivery cycle timing and flowrate may vary based on the observations made during testing, and the total amendment needed may vary based on the recirculation period required (as determined in Phase 1).

The period of recirculation during this phase is anticipated to take approximately 1 month, but may be adjusted based on the results of tracer testing during Phase 1. After active recirculation, groundwater in the treatment zone will be monitored for approximately 3 months to evaluate whether microorganisms are stimulated and EDB degradation is enhanced. This evaluation will utilize all available data including EDB concentrations, reduced gas concentrations, CSIA, QuantArray, bromide/chloride ratios, and substrate consumption.

Six sampling events are anticipated during Phase 2; three will be conducted during the active recirculation period, followed by three monthly events during the passive monitoring period. The analytes to be measured are described in Section 3.4.3. The concentrations of iodide and volatile fatty acids (VFA) (including lactate and its initial degradation product acetate) will be monitored as indicators of amendment distribution during this phase.

### 3.4.1.3 Evaluation of Bioaugmentation – Phase 3

Like previous phases, Phase 3 consists of two periods, a recirculation/mixing period, and a subsequent passive monitoring period. If necessary, and similar to Phase 2, a concentrated solution of sodium lactate with nutrients will be prepared in a feed tank so that average injection concentrations (amendment feed mixed with recirculated groundwater) of approximately 300 mg/L lactate and 100 mg/L DAP are attained.
Depending on performance during previous phases, a conservative dye tracer (e.g., fluorescein) may be included with the amendments to evaluate their distribution. Additionally, approximately 200 liters of CB&I’s SDC-9 bioaugmentation culture will be injected into KAFB-106IN1 as a single batch and distributed with the recirculation system. If pH values decrease below 5.5, a dilute sodium carbonate solution will be added to neutralize pH. A pulsed amendment injection scenario will be implemented to minimize any potential biofouling in the injection well. Similar to Phase 2, it is anticipated that the amendments will be delivered for 80 minutes during a two-hour cycle, equating to the same amendment flowrate and total volume as presented in the previous section. The amendment delivery cycle timing and flowrate may vary based on the observations made during testing, and the total amendment needed may vary based on the recirculation period required (as verified in Phase 1 and Phase 2).

The period of recirculation during this phase is anticipated to take approximately 1 month. After active recirculation, groundwater in the treatment zone will be monitored for approximately 3 months to evaluate whether EDB degradation is enhanced via bioaugmentation, as was observed in laboratory studies (refer to Figure 2). Six sampling events are anticipated during Phase 3; three will be conducted during the active recirculation period, followed by three during the passive monitoring period. The analytes to be measured are described in Section 3.4.3. The concentrations of VFAs, (including lactate and its initial degradation product acetate) and the conservative dye tracer (if used) will be monitored as indicators of amendment distribution during this phase.

### 3.4.1.4 Rebound Monitoring – Phase 4

After the conclusion of Phase 3 testing, the treatment system will be monitored for an extended period of time (at least 6 months) to evaluate long-term performance of the technology and to quantify any rebound of EDB. It is anticipated that three bi-monthly sampling events will be performed during Phase 4.

### 3.4.2 Contingencies for Biofouling

The groundwater extracted and reinjected during this pilot test will be anaerobic, and the risk of excessive microbial growth and biofouling is lower than when such water is aerobic. However, as mentioned in Section 3.4.1, in an attempt to minimize the potential for biofouling, amendments will be added to the aquifer in pulses during the groundwater recirculation phases, rather than via continuous addition. An additional slug of groundwater without amendments will be recirculated at the end of the Phase 2 and Phase 3 recirculation/mixing periods to reduce concentrations of lactate and nutrients near the injection well screen and filter pack. The overall plan of phased recirculation, rather than continuous groundwater recirculation throughout the demonstration, is also designed to reduce the biofouling risk. Fouling impacts to performance will be evaluated through drawdown and mounding measurements at the extraction and injection wells, as well as changes in normal operating pressures using the SCADA system. Additionally, drawdown in the extraction wells will be limited such that screens will remain submerged to minimize aeration of extracted water. If fouling of the injection well is found to impact the performance of any phase of the pilot test, a conference call will be initiated among USACE, CB&I, USAF, and the NMED. Responses to problematic changes in well performance may include adjustments to pumping and injection rates together with adjustments to the time periods of recirculation and amendment delivery. Additionally, if well redevelopment is deemed necessary, an addendum work plan will be developed and submitted to the NMED.

### 3.4.3 Sampling Plan

This section addresses sampling for the in situ pilot test. All activities will be conducted in accordance with Sections 5.2.4 and 5.2.5 of the Groundwater Investigation Work Plan (USACE, 2011), and the site-specific Quality Assurance Project Plan, which is an appendix to the Groundwater Investigation Work Plan.
Groundwater monitoring during the pilot testing will include measuring field parameters (e.g., pH, temperature, dissolved oxygen, oxidation reduction potential, turbidity, and specific conductance) using field meters. Aqueous samples will be collected to monitor δ2H of the water, dye tracer concentrations, EDB, volatile organic compounds (VOCs), reduced gases (methane, ethane, ethene), VFAs, dissolved iron (Fe) and manganese (Mn), anions (including bromide and iodide), and alkalinity. In addition, samples will be collected at select times to conduct compound-specific isotope analysis (CSIA) of EDB carbon (δ13C), and to evaluate microbial community structure, mainly populations of specific dehalogenating bacteria. Sampling locations and frequency are discussed in Section 3.4.3.3.

3.4.3.1 Groundwater Sampling

Groundwater sampling work for the pilot test consists of measuring for the presence of LNAPL, measuring groundwater levels, and using low-flow purging and sampling to collect representative groundwater samples for field and laboratory analysis.

3.4.3.1.1 Measuring Groundwater and LNAPL Depths

Depth to water and depth to LNAPL (if present) will be measured in each groundwater monitoring well using an electronic, oil-water interface probe, or similar device in accordance with Section 5.2.1 of the Groundwater Investigation Work Plan (USACE, 2011). Measurements will be made immediately before and during purging of a well for sampling.

3.4.3.1.2 General Pre-Sampling Field Activities

Procedures for pre-sampling field activities will follow those outlined in Section 5.2.3 of the Groundwater Investigation Work Plan (USACE, 2011) and Sections 6 and 7 of the Accident Prevention Plan (APP), (USACE, 2015d).

3.4.3.1.3 Monitoring Well Purging

All sample monitoring wells will be purged using low-flow purging techniques before sample collection. Low-flow purging will follow the procedures outlined in the ASTM standard D6452-99 (ASTM, 2012), Section 7.5 on low-flow purging and sampling.

Field parameters (including turbidity) will be measured during purging using a flow-through cell water quality parameter meter (or equivalent). Sampling and analysis requirements are outlined in Section 3.4.3.4 below.

3.4.3.2 Decontamination

Decontamination of all groundwater sampling and measurement equipment will include washing with Alconox®, or similar, and a subsequent rinse with deionized water. Dedicated sampling equipment will not require pre-sampling decontamination once installed into wells. Decontamination is required for all measurement or sampling equipment prior to reuse in any site wells.

3.4.3.3 Groundwater Sampling Locations and Frequency

The analytical sampling described in Sections 3.4.1 will be performed at the locations and frequency described in Table 3. Sample locations and frequency may, pending investigation and field results, be modified.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Analyte</th>
<th>Locations</th>
<th>Approximate Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1</strong>&lt;br&gt;(Section 2.4.1.1)</td>
<td>Water Isotopes ($\delta^2$H) and Dye Tracer (Fluorescein)</td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>1 event (baseline)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs</td>
<td>8 events (recirculation, collected on Days 2, 4, 7, 10, 14, 18, 23, and 30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>2 events (passive, collected during Weeks 2 and 4)</td>
</tr>
<tr>
<td></td>
<td>Microbial Community</td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>1 event (baseline)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td>CSIA</td>
<td>3 MWs, 2 EWs</td>
<td>1 event (baseline)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td>All Other Analytes $^b$</td>
<td>6 MWs, 2 EWs</td>
<td>1 event (baseline)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs</td>
<td>1 event (passive, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>3 events (recirculation, collected during Weeks 2, 3, and 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 events (passive, collected at end of Months 1, 2, and 3)</td>
</tr>
<tr>
<td><strong>Phase 2</strong>&lt;br&gt;(Section 2.4.1.2)</td>
<td>Microbial Community</td>
<td>6 MWs, 2 EWs</td>
<td>1 event (recirculation, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected at end of Month 3)</td>
</tr>
<tr>
<td></td>
<td>CSIA</td>
<td>3 MWs, 2 EWs</td>
<td>1 event (recirculation, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected at end of Month 3)</td>
</tr>
<tr>
<td></td>
<td>All Other Analytes $^b$</td>
<td>6 MWs, 2 EWs</td>
<td>3 events (recirculation, collected during Weeks 2, 3, and 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>3 events (passive, collected at end of Months 1, 2, and 3)</td>
</tr>
<tr>
<td><strong>Phase 3</strong>&lt;br&gt;(Section 2.4.1.3)</td>
<td>Dye Tracer (Fluorescein)</td>
<td>6 MWs, 2 EWs</td>
<td>3 events (recirculation, collected during Weeks 2, 3, and 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>3 events (passive, collected at end of Months 1, 2, and 3)</td>
</tr>
<tr>
<td></td>
<td>Microbial Community</td>
<td>6 MWs, 2 EWs</td>
<td>1 event (recirculation, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected at end of Month 3)</td>
</tr>
<tr>
<td></td>
<td>CSIA</td>
<td>3 MWs, 2 EWs</td>
<td>1 event (recirculation, collected during Week 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected at end of Month 3)</td>
</tr>
<tr>
<td></td>
<td>All Other Analytes $^b$</td>
<td>6 MWs, 2 EWs</td>
<td>3 events (recirculation, collected during Weeks 2, 3, and 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>3 events (passive, collected at end of Months 1, 2, and 3)</td>
</tr>
</tbody>
</table>
Table 3. Groundwater Sampling Schedule (concluded)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Analyte</th>
<th>Locations</th>
<th>Approximate Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 4 (Section 2.4.1.4)</td>
<td>Microbial Community</td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>1 event (passive, collected at the end of Month 4)</td>
</tr>
<tr>
<td></td>
<td>CSIA</td>
<td>3 MWs</td>
<td>1 event (passive, collected at the end of Month 4)</td>
</tr>
<tr>
<td></td>
<td>All Other Analytes b</td>
<td>6 MWs, 2 EWs, 1 IW</td>
<td>3 events (passive, collected at the end of Months 2, 4, and 6)</td>
</tr>
</tbody>
</table>

a 4 MWs = KAFB-106064, KAFB-106063, KAFB-106MW1, KAFB-106MW2
2 EWs = KAFB-106EX1, KAFB-106EX2
1 IW = KAFB-106IN1

b EDB, VOCs, reduced gases, anions (including bromide and iodide), VFAs, dissolved Fe/Mn, alkalinity

c The frequency provided is approximate and may be adjusted to collect samples closer together or further apart based on operating conditions and sample results.
d Includes shallow monitoring wells KAFB-106064, KAFB-106MW1-S, and KAFB-106MW2-S

3.4.3.4 Analytical and Sample Preservation for Groundwater Samples

The analytical methods, sample preservation, bottleware, and holding times used for the analyses that will be part of this pilot test are summarized in Table 4 below.

Table 4. Analytical Methods, Preservation, Containers, and Holding Times - Groundwater

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Method/Laboratory</th>
<th>Preservative</th>
<th>Bottle</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDB</td>
<td>EPA 8011</td>
<td>6°C</td>
<td>40-mL VOA vial (x3)</td>
<td>14 days</td>
</tr>
<tr>
<td>EDB δ¹³C via CSIA</td>
<td>Kuder et al, 2012</td>
<td>6°C with HCl</td>
<td>1-liter amber glass screw-cap (x2)</td>
<td>--</td>
</tr>
<tr>
<td>δ⁷H</td>
<td>Hydrogen/H₂O Equilibration Isotope Ratio Mass Spectrometry (USGS Reston, VA)</td>
<td>6°C</td>
<td>40-mL VOA vial (x2)</td>
<td>--</td>
</tr>
<tr>
<td>VOCs</td>
<td>EPA 8260B</td>
<td>6°C with HCl</td>
<td>40-mL VOA vial (x3)</td>
<td>14 days</td>
</tr>
<tr>
<td>Reduced Gases</td>
<td>RSKSOP-175</td>
<td>6°C with HCl</td>
<td>40-mL VOA vial (x2)</td>
<td>14 days</td>
</tr>
<tr>
<td>Dye Tracer (Fluorescein)</td>
<td>Spectrofluorophotometry (Crawford Hydrology Lab, Ozark Underground Lab)</td>
<td>6°C</td>
<td>40+ mL water vials (x2)</td>
<td>--</td>
</tr>
<tr>
<td>Anions (with Bromide, Iodide)</td>
<td>EPA 300.0</td>
<td>6°C</td>
<td>100-mL polyethylene screw-cap (x1)</td>
<td>28 days</td>
</tr>
<tr>
<td>Nitrate</td>
<td>EPA 353.2</td>
<td>6°C with H₂SO₄</td>
<td>250-mL polyethylene screw-cap (x1)</td>
<td>28 days</td>
</tr>
<tr>
<td>Phosphate</td>
<td>SM4500 PE</td>
<td>6°C</td>
<td>100-mL polyethylene screw-cap (x1)</td>
<td>48 hours</td>
</tr>
<tr>
<td>Volatile Fatty Acids</td>
<td>EPA 300m</td>
<td>6°C</td>
<td>40-mL VOA vial (x2)</td>
<td>14 days</td>
</tr>
</tbody>
</table>
Table 4. Analytical Methods, Preservation, Containers, and Holding Times – Groundwater (concluded)

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Method/Laboratory</th>
<th>Preservative</th>
<th>Bottle</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dissolved Metals (Fe, Mn)</strong></td>
<td>EPA 6010C (Empirical)</td>
<td>Capsule filter, 6°C with HNO₃</td>
<td>100-mL polyethylene screw-cap (x1)</td>
<td>6 months</td>
</tr>
<tr>
<td><strong>Alkalinity</strong></td>
<td>SM 2320B (Empirical)</td>
<td>6°C</td>
<td>500-mL polyethylene screw-cap (x1)</td>
<td>14 days</td>
</tr>
<tr>
<td><strong>Microbial Community</strong></td>
<td>QuantArray-Chlor (Microbial Insights)</td>
<td>6°C</td>
<td>1-liter amber glass screw-cap (x2)</td>
<td>48 hours</td>
</tr>
<tr>
<td>- Dissolved Oxygen</td>
<td>Field Meter</td>
<td>-- b</td>
<td>-- b</td>
<td>-- b</td>
</tr>
<tr>
<td>- pH</td>
<td></td>
<td>-- b</td>
<td>-- b</td>
<td>-- b</td>
</tr>
<tr>
<td>- Oxidation-Reduction Potential</td>
<td></td>
<td>-- b</td>
<td>-- b</td>
<td>-- b</td>
</tr>
<tr>
<td>- Conductivity</td>
<td></td>
<td>-- b</td>
<td>-- b</td>
<td>-- b</td>
</tr>
<tr>
<td>- Temperature</td>
<td></td>
<td>-- b</td>
<td>-- b</td>
<td>-- b</td>
</tr>
<tr>
<td>- Turbidity</td>
<td></td>
<td>-- b</td>
<td>-- b</td>
<td>-- b</td>
</tr>
</tbody>
</table>

a Laboratory method has not been approved by the EPA; therefore, a holding time has not been established.
b Field parameters collected during purging and sampling of the well.
°C degrees Celsius
Empirical Empirical Laboratories LLC
EPA U.S. Environmental Protection Agency
HCl hydrochloric acid
H₂SO₄ sulfuric acid
HNO₃ nitric acid
mL milliliter
VOA volatile organic analysis

3.4.3.5 Quality Assurance for Groundwater Sampling and Analysis

The following sections describe the quality assurance procedures that will be used for groundwater sampling and analysis.

3.4.3.5.1 Calibration Procedures and Frequency

All field and laboratory instruments will be calibrated according to manufacturers’ specifications. All CB&I instruments will be calibrated in accordance with established standard operating procedures and manufacturers’ recommendations. Calibration will be performed 1 hour prior to initial use and after periods of non-use exceeding 4 hours. A record of calibration will be made in the field logbook each time a field instrument is calibrated.

3.4.3.5.2 Field Water Quality Measurements

Groundwater will be assessed for dissolved oxygen, pH, oxidation-reduction potential, conductivity, temperature, and turbidity with field water quality meters. The field water quality meters will be calibrated at the beginning of each day and as necessary thereafter if anomalous readings are observed for any parameter.
3.4.3.5.3 Laboratory Measurements

The calibration procedures for off-site analyses will follow the established U.S. Environmental Protection Agency SW-846 guidelines for the specific method, where applicable. Certified standards will be used for calibrations and calibration check measurements, where applicable. A separate laboratory calibration record will be maintained by laboratory quality assurance personnel.

3.4.3.5.4 Quality Control Samples

Internal quality control (QC) data provide information for identifying and defining qualitative and quantitative limitations associated with measurement data. Field QC samples include field duplicates and trip blanks. The frequency of field QC sample collections will be in accordance with Section 5.2.6 of the Groundwater Investigation Work Plan (USACE, 2011).

Field duplicates will be collected at a frequency of 10% of the total number of laboratory samples and will be analyzed for $\delta^{2}$H and/or dye tracers, EDB, VOCs, reduced gases, anions, VFAs, dissolved Fe/Mn, and alkalinity. These frequencies are in accordance with Section 5.2.6 of the Groundwater Investigation Work Plan (USACE, 2011). Trip blank samples will be shipped with coolers containing samples for EDB or VOC analysis.

3.4.3.5.5 Sample Documentation

Sample-collection logs, purge logs, chain-of-custody forms, and any other applicable field forms will be filled out by the sample technician during monitoring and sampling activities. See example field forms in Appendix C.

The on-site field technician or project chemist will coordinate with the off-site laboratories for shipment and receipt of sample bottles, coolers, ice packs, chain-of-custody forms, and custody seals. All project-related data will be maintained and archived in the electronic project files and will be uploaded to the USAF Environmental Resources Program Information Management System (also known as ERPIMS) as appropriate.

3.4.4 Investigation-Derived Waste Containment and Disposal

All investigation-derived waste (IDW) generated during implementation of the in situ pilot test will be handled and disposed of according to the Waste Management Plan of the Groundwater Investigation Work Plan (USACE, 2011) with the following variances:

- All liquid IDW will be characterized analytically before disposal.

- Non-hazardous liquid IDW will be disposed of at the GWTS if it meets the criteria specified in the document pertaining to the operation of that system (USACE, 2016). If the IDW analytical does not meet the criteria, the waste will be disposed of off-site at a licensed facility. Non-hazardous liquid IDW treated through the GWTS will be documented (i.e., including origin, quality, and volume) and reported in Kirtland AFB BFF quarterly reports.

- All hazardous IDW will be disposed of off-site at a RCRA permitted hazardous waste facility.

- No liquid IDW will be discharged to land surfaces.
3.5 Data Analyses and Reporting

Water $\delta^{2}H$ values, dye-tracer concentrations, iodide-tracer concentrations, and VFA concentrations during Phases 1, 2, and 3 will help constrain transport times and distribution/dilution (by mixing ratios) during and subsequent to active recirculation. During Phases 2 through 4, changes in EDB and reduced gas (e.g., ethene and ethane) concentrations, EDB carbon isotope ratios, and bromide/chloride ratios will be used to quantify EDB degradation performance of the system. Reductive dehalogenation of EDB can be evaluated by decreases in EDB concentrations and increases in concentrations of degradation products including ethene, ethane, and bromide. Additionally, carbon isotope fractionation during reductive dehalogenation will result in increased $\delta^{13}C$ values of EDB, which will be monitored by CSIA. Microbial analyses during these phases will be used to track changes in the microbial community, and correlations of various microorganism populations with EDB degradation will be explored. Degradation during the multiple test phases will be compared to evaluate whether enhanced ISB is a suitable approach for enhancing EDB degradation in situ.

The established LNAPL Biogeochemistry Working Group will be used as a discussion platform to update NMED on the progress regarding the pilot test. Data, presentations, and other meeting materials will be provided, after USACE and AFCEC review, several days prior to the meeting. Subsequent phases of testing will continue on schedule during update discussions at the working group.

A Final Report describing the performance of the recirculation system will be prepared for USAF and USACE, and associated in situ bioremediation efforts will be provided to the USAF, USACE, and NMED after completion of the field studies.

4.0 MANAGEMENT AND STAFFING

Table 5 below lists the key project personnel and their responsibilities.

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Position</th>
<th>Office</th>
<th>Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathleen Romalia</td>
<td>Program Manager (Rapid Response Contract)</td>
<td>303-486-2510</td>
<td>720-989-1154</td>
</tr>
<tr>
<td>Paul Koster van Groos</td>
<td>Principal Investigator/Project Manager (ESTCP)</td>
<td>609-895-5367</td>
<td>734-678-3344</td>
</tr>
<tr>
<td>Paul Hatzinger</td>
<td>Co-Principal Investigator (ESTCP)</td>
<td>609-895-5356</td>
<td>267-337-4003</td>
</tr>
<tr>
<td>Graig Lavorgna</td>
<td>System Design/Operations</td>
<td>609-895-5343</td>
<td>908-309-7651</td>
</tr>
<tr>
<td>Tara Kunkel</td>
<td>Albuquerque Project Manager</td>
<td>505-262-8906</td>
<td>505-967-9521</td>
</tr>
<tr>
<td>Bruce Burke</td>
<td>Field Operations Supervisor</td>
<td>561-429-5375</td>
<td>561-309-7599</td>
</tr>
<tr>
<td>Caitlin LaChance</td>
<td>Field Operations Coordinator</td>
<td>505-262-8942</td>
<td>505-328-4710</td>
</tr>
<tr>
<td>Crystal Hardee</td>
<td>Field Ops and Procurement Support</td>
<td>505-262-8930</td>
<td>505-340-9336</td>
</tr>
<tr>
<td>R. Paul Philp</td>
<td>Technical Support</td>
<td>405-325-4469</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Doug Russell</td>
<td>Health &amp; Safety</td>
<td>865-560-7918</td>
<td>865-414-9545</td>
</tr>
<tr>
<td>Susan Huang</td>
<td>Project Chemist</td>
<td>925-288-2099</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

4.1 Organizational Chart with Key Personnel

The key personnel and contractors involved in this project (including contact information) are summarized on Figure 8, and details on their primary responsibilities are provided in Section 3.2.
Figure 8. Project Organizational Chart
4.2 Roles and Responsibilities

Ms. Kathleen Romalia is a Senior Project Manager (PM) with CB&I in Greenwood Village, Colorado. She manages CB&I’s Rapid Response Contract with USACE through which the EDB pilot test is funded.

Dr. Paul Koster van Groos serves as the Principal Investigator (PI) and PM for ESTCP project ER-201331 associated with this work. Dr. Koster van Groos has more than 10 years of environmental remediation, assessment, engineering, and research experience in industry and academia. Dr. Koster van Groos is a former Fulbright and U.S. Environmental Protection Agency STAR fellow and has significant experience examining pollutant fate and transport, and environmental forensics. This experience includes examination of various stable isotope effects and degradation of emerging contaminants including EDB.

Dr. Paul Hatzinger has served as the PI on many Strategic Environmental Research and Development Program and ESTCP projects, and serves as a co-PI on ESTCP project ER-201331. Dr. Hatzinger is Director of CB&I’s Biotechnology Development and Applications Group located in Lawrenceville, New Jersey, and has more than 20 years of experience implementing and assessing bioremediation. He has significant experience in the area of stable isotope analysis, bioremediation, and EDB biodegradation. He will work with Dr. Koster van Groos on test design and data analysis.

Mr. Graig Lavorgna is a Senior Environmental Engineer with CB&I’s Biotechnology Development and Applications Group. He will lead system design and operations on this project. Mr. Lavorgna has over 19 years of experience in the design, implementation, and management of in situ remediation projects, including numerous projects involving bioremediation. He currently serves as PM and engineer on several on-going ESTCP projects.

Dr. Paul Philp and Dr. Tomasz Kuder of the University of Oklahoma are recognized experts in CSIA techniques and applying the technology to analyze chlorinated solvent remediation. They have developed, and continue to develop, CSIA techniques specifically for EDB, and they have significant experience working on the Strategic Environmental Research and Development Program and ESTCP projects.

Ms. Tara Kunkel is a Geological Scientist and Operations Manager with CB&I in Albuquerque, New Mexico. She will serve as the Albuquerque Project Manager and Operations Manager on this project. She has significant experience working with USAF and USACE at Kirtland AFB and has served as the operations manager and task lead on an additional pilot study at Kirtland AFB.

Mr. Bruce Burke is a Construction Manager with CB&I based in Miami Lakes, Florida. He will serve as the construction manager for the well and system installation. Mr. Burke has more than 25 years of experience as a construction manager running construction and environmental government projects and has substantial experience working with USAF and USACE at Kirtland AFB.

Ms. Caitlin LaChance is a Geological Scientist with CB&I in Albuquerque, New Mexico. She will serve as the field operations coordinator on this project. She has significant experience working with USAF and USACE at Kirtland AFB where the field study will be conducted.

Ms. Crystal Hardee is an Environmental Scientist with CB&I in Albuquerque, New Mexico. She will serve as a procurement specialist and assist with field operations. She has substantial experience working with USAF and USACE at Kirtland AFB.

Ms. Susan Huang is a Project Chemist with CB&I in Concord, California. She will review data quality from both CB&I’s laboratory and any outside contract laboratories used for this effort.
Mr. Doug Russell is a Health and Safety Professional with CB&I and serves as the project’s overall Health, Safety, and Environmental Manager. Mr. Russell, one of CB&I’s Health and Safety Professionals for Kirtland AFB, will be responsible for revising and approving changes to the site’s APP based on this project’s unique field requirements.

Other field, contracting, health & safety, and financial personnel from CB&I will participate in the project as required. Drilling will be conducted by a New Mexico-certified driller based on a competitive bid process.
REFERENCES


### ACRONYMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>percent</td>
</tr>
<tr>
<td>‰</td>
<td>per mille</td>
</tr>
<tr>
<td>Δ(^{13})C</td>
<td>delta carbon-13 (measure of carbon isotope composition)</td>
</tr>
<tr>
<td>Δ(^2)H</td>
<td>delta deuterium (measure of hydrogen isotope composition)</td>
</tr>
<tr>
<td>(^{13})C</td>
<td>carbon-13, stable isotope of carbon</td>
</tr>
<tr>
<td>(^2)H</td>
<td>deuterium, stable isotope of hydrogen</td>
</tr>
<tr>
<td>(^2)H(_2)O</td>
<td>deuterium oxide, deuterated water</td>
</tr>
<tr>
<td>1,2-DCA</td>
<td>1,2-dichloroethane</td>
</tr>
<tr>
<td>AFB</td>
<td>Air Force Base</td>
</tr>
<tr>
<td>BFF</td>
<td>Bulk Fuels Facility</td>
</tr>
<tr>
<td>bgs</td>
<td>below ground surface</td>
</tr>
<tr>
<td>CB&amp;I</td>
<td>CB&amp;I Federal Services LLC</td>
</tr>
<tr>
<td>CSIA</td>
<td>compound-specific isotope analysis</td>
</tr>
<tr>
<td>CSS</td>
<td>Colorado silica sand</td>
</tr>
<tr>
<td>DAP</td>
<td>diammonium phosphate</td>
</tr>
<tr>
<td>DoD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>EDB</td>
<td>ethylene dibromide/1,2-dibromoethane</td>
</tr>
<tr>
<td>ESTCP</td>
<td>Environmental Security Technology Certification Program</td>
</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>FCV</td>
<td>flow-control valve</td>
</tr>
<tr>
<td>gpm</td>
<td>gallon per minute</td>
</tr>
<tr>
<td>GWTS</td>
<td>groundwater treatment system</td>
</tr>
<tr>
<td>IDW</td>
<td>investigation-derived waste</td>
</tr>
<tr>
<td>ISB</td>
<td>in situ bioremediation</td>
</tr>
<tr>
<td>KAFB</td>
<td>Kirtland Air Force Base</td>
</tr>
<tr>
<td>LNAPL</td>
<td>light non-aqueous phase liquid</td>
</tr>
<tr>
<td>lbs</td>
<td>pounds</td>
</tr>
<tr>
<td>mg/L</td>
<td>milligram per liter</td>
</tr>
<tr>
<td>Mn</td>
<td>manganese</td>
</tr>
<tr>
<td>NMED</td>
<td>New Mexico Environment Department</td>
</tr>
<tr>
<td>PI</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>PM</td>
<td>Project Manager</td>
</tr>
<tr>
<td>PVC</td>
<td>polyvinylchloride</td>
</tr>
<tr>
<td>QC</td>
<td>quality control</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>USACE</td>
<td>U.S. Army Corps of Engineers</td>
</tr>
<tr>
<td>USAF</td>
<td>U.S. Air Force</td>
</tr>
<tr>
<td>VFA</td>
<td>volatile fatty acid</td>
</tr>
<tr>
<td>VOC</td>
<td>volatile organic compound</td>
</tr>
</tbody>
</table>
I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

DAWN A. NICKELL, Colonel, USAF
Vice Commander, 377th Air Base Wing

This document has been approved for public release.

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs
APPENDIX A

Draft System Design Diagrams
Conceptual Monitoring Well Design

Not to Scale

BGS = Below Ground Surface
APPENDIX B

Safety Data Sheets for Amendments and Tracers
DEUTERIUM OXIDE "100%" (D, 99.96%)
Safety Data Sheet
according to Regulation (EC) No. 453/2010 and according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

Date of issue: 30/09/2014
Revision date: 28/07/2015
Supersedes: 04/06/2015
Version: 4

DLM-6

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier
Product form : Substance
Substance name : DEUTERIUM OXIDE "100%" (D, 99.96%)
EC no : 231-791-2
CAS No : 7789-20-0
Product code : DLM-6
Formula : D2O

1.2. Relevant identified uses of the substance or mixture and uses advised against
1.2.1. Relevant identified uses
No additional information available

1.2.2. Uses advised against
No additional information available

1.3. Details of the supplier of the safety data sheet
Cambridge Isotope Laboratories, Inc.
50 Frontage Road
Andover, MA 01810
USA
USA: 1-800-322-1174  Int: 1-978-749-8000
cilsales@isotope.com  www.isotope.com

Emergency telephone number
Emergency numbers:
Chemtrec: 1-800-424-9300 (24 hours)
International: 1-703-741-5970 (24 hours)

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture
Classification according to Regulation (EC) No. 1272/2008 [CLP]
Not classified

Classification according to Directive 67/548/EEC or 1999/45/EC
Not classified

Classification (GHS-US)
Not classified

Adverse physicochemical, human health and environmental effects
No additional information available

2.2. Label elements
Labeling according to Regulation (EC) No. 1272/2008 [CLP]
No labeling applicable

GHS-US labeling
No labeling applicable

2.3. Other hazards
No additional information available
### SECTION 3: Composition/information on ingredients

#### 3.1. Substances

<table>
<thead>
<tr>
<th>Name</th>
<th>Product identifier</th>
<th>%</th>
<th>Classification according to Directive 67/548/EEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEUTERIUM OXIDE &quot;100%&quot; (D, 99.96%) (Main constituent)</td>
<td>(CAS No) 7789-20-0 (EC no) 231-791-2</td>
<td>100</td>
<td>Not classified</td>
</tr>
</tbody>
</table>

#### 3.2. Mixtures

Not applicable

### SECTION 4: First aid measures

#### 4.1. Description of first aid measures

- **First-aid measures after inhalation**
  - If not breathing give artificial respiration.

- **First-aid measures after ingestion**
  - Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

#### 4.2. Most important symptoms and effects, both acute and delayed

No additional information available

#### 4.3. Indication of any immediate medical attention and special treatment needed

No additional information available

### SECTION 5: Firefighting measures

#### 5.1. Extinguishing media

- **suitable extinguishing media**
  - Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

#### 5.2. Special hazards arising from the substance or mixture

- **Reactivity**
  - Not available.

#### 5.3. Advice for firefighters

- **Firefighting instructions**
  - The product itself does not burn.

- **Protection during firefighting**
  - Do not enter fire area without proper protective equipment, including respiratory protection.

### SECTION 6: Accidental release measures

#### 6.1. Personal precautions, protective equipment and emergency procedures

- **For non-emergency personnel**
  - No additional information available

- **For emergency responders**
  - No additional information available

#### 6.2. Environmental precautions

- Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

#### 6.3. Methods and material for containment and cleaning up

- **For containment**
  - Wipe up with absorbent material (e.g. cloth, fleece).

#### 6.4. Reference to other sections

No additional information available

### SECTION 7: Handling and storage

#### 7.1. Precautions for safe handling

- **Hygiene measures**
  - Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.
DEUTERIUM OXIDE "100%" (D, 99.96%)  DLM-6  
Safety Data Sheet  
according to Regulation (EC) No. 453/2010 and according to Federal Register / Vol. 77, No. 58 / Monday, March 26, 2012 / Rules and Regulations

SECTION 7: Physical and chemical properties

9.1. Information on basic physical and chemical properties

- Physical state: Liquid
- Appearance: Liquid.
- Molecular mass: 20.03
- Color: Colourless.
- Odor: No data available.
- Odor threshold: No data available
- pH: 6.0 - 8.0 at 25 °C (77 °F)
- Relative evaporation rate (butyl acetate=1): No data available
- Melting point: 0.0 °C (32.0 °F)
- Freezing point: No data available
- Boiling point: 100.0 °C (212.0 °F)
- Flash point: No data available
- Self ignition temperature: No data available
- Decomposition temperature: No data available
- Flammability (solid, gas): No data available
- Vapor pressure: No data available
- Relative vapor density at 20 °C: No data available
- Relative density: No data available
- Density: 1.11 g/m³ at 20 °C (68 °F)
- Solubility: Water: Completely miscible
- Log Pow: No data available
- Log Kow: No data available
- Viscosity, kinematic: No data available
- Viscosity, dynamic: No data available
- Explosive properties: No data available
- Oxidizing properties: No data available
- Explosive limits: No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

Not available.

10.2. Chemical stability

Stable if stored under recommended conditions.
10.3. Possibility of hazardous reactions
No additional information available

10.4. Conditions to avoid
Not available.

10.5. Incompatible materials
No data available.

10.6. Hazardous decomposition products
No data available.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

<table>
<thead>
<tr>
<th>Acute toxicity</th>
<th>Not classified</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD50 oral rat</td>
<td>&gt; 90000 mg/kg</td>
</tr>
</tbody>
</table>

Skin corrosion/irritation
- Not classified
- pH: 6.0 - 8.0 at 25 °C (77 °F)

Serious eye damage/irritation
- Not classified
- pH: 6.0 - 8.0 at 25 °C (77 °F)

Respiratory or skin sensitization
- Not available

Germ cell mutagenicity
- Not available

Carcinogenicity
- Not classified

Reproductive toxicity
- Not available

Specific target organ toxicity (single exposure)
- Not classified
- No data available

Specific target organ toxicity (repeated exposure)
- Not classified
- No data available

Aspiration hazard
- Not classified

Potential Adverse human health effects and symptoms
- To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

SECTION 12: Ecological information

12.1. Toxicity
No additional information available

12.2. Persistence and degradability

<table>
<thead>
<tr>
<th>DEUTERIUM OXIDE &quot;100%&quot; (D, 99.96%) (7789-20-0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence and degradability</td>
</tr>
</tbody>
</table>

12.3. Bioaccumulative potential

<table>
<thead>
<tr>
<th>DEUTERIUM OXIDE &quot;100%&quot; (D, 99.96%) (7789-20-0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioaccumulative potential</td>
</tr>
</tbody>
</table>

12.4. Mobility in soil

<table>
<thead>
<tr>
<th>DEUTERIUM OXIDE &quot;100%&quot; (D, 99.96%) (7789-20-0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology - soil</td>
</tr>
</tbody>
</table>

12.5. Results of PBT and vPvB assessment
No additional information available

12.6. Other adverse effects
Other adverse effects
- Not available.
### SECTION 13: Disposal considerations

**13.1. Waste treatment methods**

Regional legislation (waste) : Waste materials should be disposed of under conditions which meet Federal, State, and Local environmental control regulations.

### SECTION 14: Transport information

In accordance with ADR / RID / ADNR / IMDG / ICAO / IATA

**14.1. UN number**

Not applicable

**14.2. UN proper shipping name**

Not applicable

**14.3. Additional information**

Other information : No supplementary information available.

Special transport precautions : Not dangerous goods.

#### Overland transport

No additional information available

#### Transport by sea

No additional information available

#### Air transport

No additional information available

**14.4. Environmental hazards**

Other information : No supplementary information available.

**14.5. Special precautions for user**

Special transport precautions : Not dangerous goods.

**14.6. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code**

Not applicable

### SECTION 15: Regulatory information

**15.1. US Federal regulations**

No additional information available

**15.2. International regulations**

**CANADA**

**DEUTERIUM OXIDE "100%" (D, 99.96%) (7789-20-0)**

Listed on the Canadian DSL (Domestic Substances List) inventory.

**15.2.1. National regulations**

No additional information available

**15.3. US State regulations**

**DEUTERIUM OXIDE "100%" (D, 99.96%)(7789-20-0)**

State or local regulations

<table>
<thead>
<tr>
<th></th>
<th>U.S. - Pennsylvania - RTK (Right to Know) List</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U.S. - New Jersey - Right to Know Hazardous Substance List</td>
</tr>
<tr>
<td>This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.</td>
<td></td>
</tr>
</tbody>
</table>
SECTION 16: Other information

Other information: This product is not radioactive. The data given for this product are those of the corresponding unlabeled compound, unless specifically indicated otherwise. Health and safety data for labeled compounds are generally not available, but are assumed to be similar or identical to the corresponding unlabeled compound.

NFPA health hazard: 0 - Exposure under fire conditions would offer no hazard beyond that of ordinary combustible materials.
NFPA fire hazard: 0 - Materials that will not burn.
NFPA reactivity: 0 - Normally stable, even under fire exposure conditions, and are not reactive with water.

HMIS III Rating
Health: 0 Minimal Hazard - No significant risk to health
Flammability: 0 Minimal Hazard
Physical: 0 Minimal Hazard

CIL Multi-Solvent Mixture SDS

This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. It should not therefore be construed as guaranteeing any specific property of the product.
MATERIAL SAFETY DATA SHEET
GREENVILLE COLORANTS, L.L.C.

SECTION I: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

TRADE NAME: ELACID EOSINE OJ POWDER 15189
CHEMICAL FAMILY: XANTHENE DYE
MANUFACTURER/DISTRIBUTOR: GREENVILLE COLORANTS, L.L.C.
20 LINDEN AVE EAST
JERSEY CITY, NEW JERSEY 07305
PHONE NUMBER: 201 595-0200
EMERGENCY PHONE NUMBER: CALL CHEMTREC – 800-424-9300
(OUTSIDE OF THE UNITED STATES CALL 703-527-3887)
DATE PREPARED: FEBRUARY 6, 2013

SECTION II: COMPOSITION/INFORMATION ON HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>CHEMICAL NAME</th>
<th>CAS NUMBER</th>
<th>% BY WT.</th>
<th>TLV/PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROPRIETARY XANTHENE DYE</td>
<td>17372-87-1</td>
<td>60-80%</td>
<td>NOT ESTABLISHED</td>
</tr>
</tbody>
</table>

SECTION III: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: CAN CAUSE EYE IRRITATION. MAY CAUSE SKIN AND RESPIRATORY IRRITATION. SYMPTOMS OF EXPOSURE TO THIS CHEMICAL INCLUDE CHEILITIS, FACIAL DERMATITIS AND STOMATITIS.

EFFECTS OF OVEREXPOSURE:
- EYE CONTACT: CAN BE IRRITATING.
- SKIN CONTACT: MAY BE IRRITATING. SYMPTOMS OF EXPOSURE TO THIS CHEMICAL INCLUDE CHEILITIS, FACIAL DERMATITIS AND STOMATITIS.
- INHALATION: NOT KNOWN.
- INGESTION: NOT KNOWN.
- CHRONIC EXPOSURE: NOT KNOWN.
- CARCINOGENICITY: REVIEWED BY IARC FOR CARCINOGENICITY AND THE DATA WAS DETERMINED TO BE INSUFFICIENT FOR AN EVALUATION OF THE COMPOUND.
- MEDICAL CONDITIONS AGGREGATED BY EXPOSURE: NOT KNOWN

PRIMARY ROUTES OF ENTRY: SKIN CONTACT, EYE CONTACT AND INHALATION.

SECTION IV: FIRST AID MEASURES

EYE CONTACT: IMMEDIATELY FLUSH EYE WITH FLOWING WATER FOR AT LEAST 15 MINUTES, HOLDING EYELIDS APART TO IRRIGATE THOROUGHLY. GET MEDICAL ATTENTION.

SKIN CONTACT: WASH THOROUGHLY WITH SOAP AND WATER. GET MEDICAL ATTENTION IF IRRITATION DEVELOPS. REMOVE AND LAUNDER CONTAMINATED CLOTHING BEFORE REUSE.

INHALATION: REMOVE TO FRESH AIR. IF BREATHING IS DIFFICULT, GIVE OXYGEN. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. GET MEDICAL ATTENTION.

INGESTION: DILUTE WITH WATER AND INDUCE VOMITING. GET MEDICAL ATTENTION. NEVER GIVE FLUIDS OR INDUCE VOMITING IF PATIENT IS UNCONSCIOUS OR HAS CONVULSIONS.
SECTION V: FIRE FIGHTING MEASURES

FLASH POINT: NOT DETERMINED.
LOWER EXPLOSIVE LIMIT: NOT APPLICABLE.
UPPER EXPLOSIVE LIMIT: NOT APPLICABLE
AUTOIGNITION TEMPERATURE: NOT DETERMINED.

EXTINGUISHING MEDIA: WATER, DRY CHEMICAL, CARBON DIOXIDE, AND FOAM.

SPECIAL FIRE FIGHTING PROCEDURES: FIREFIGHTERS SHOULD BE EQUIPPED WITH SELF CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING.

UNUSUAL HAZARDS: DUST MAY BE EXPLOSIVE IF MIXED WITH AIR IN CRITICAL PROPORTIONS AND IN THE PRESENCE OF SOURCE OF IGNITION.

SECTION VI: ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: WEAR APPROPRIATE SAFETY EQUIPMENT. CONTAIN AND CLEAN UP SPILL IMMEDIATELY. PREVENT FROM ENTERING FLOOR DRAINS. SWEEP POWDERS CAREFULLY MINIMIZING DUSTING. SHOVEL ALL SPILL MATERIALS INTO DISPOSAL DRUMS AND FOLLOW DISPOSAL INSTRUCTIONS. SCRUB SPILL AREA WITH DETERGENT AND FLUSH WITH COPIOUS AMOUNTS OF WATER.

SECTION VII: HANDLING AND STORAGE

HANDLING: IN ACCORDANCE WITH GOOD INDUSTRIAL PRACTICES, HANDLE WITH CARE AND AVOID PERSONAL CONTACT. CONTAINERS SHOULD BE TRIPLE RINSED ACCORDING TO FEDERAL REGULATIONS AND/OR GOOD WASTE MANAGEMENT PRACTICES. FOR INDUSTRIAL USE ONLY.

STORAGE: KEEP CONTAINERS CLOSED WHEN NOT IN USE.

SECTION VIII: EXPOSURE CONTROL/PERSONAL PROTECTION

ENGINEERING CONTROLS: LOCAL EXHAUST TO MINIMIZE EXPOSURE.

RESPIRATORY PROTECTION: IF EXPOSURE TO DUST IS LIKELY, A NIOSH APPROVED DUST RESPIRATOR IS RECOMMENDED.

EXPOSURE LIMITS: NOT ESTABLISHED.

EYE PROTECTION: WEAR SAFETY GLASSES WITH SIDE SHIELDS OR SAFETY GOoggles.

SKIN PROTECTION: WEAR RUBBER GLOVES.

OTHER PROTECTIVE MEASURES: WEAR APRON, COVERALLS, BOOTS AND LONG SLEEVE SHIRT TO PREVENT SKIN CONTACT.

HYGIENIC PRACTICES: EYEWASH FOUNTAINS SHOULD BE EASILY ACCESSIBLE. SHOWER AFTER HANDLING THIS PRODUCT. WORK CLOTHES SHOULD BE WASHED BEFORE REUSE. BEFORE EATING, DRINKING, OR SMOKING, WASH HANDS AND FACE WITH SOAP AND WATER.

SECTION IX: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: POWDER.
ODOR: SLIGHT ODOR.
SOLUBILITY IN WATER: SOLUBLE.
BOILING POINT: NOT APPLICABLE.
MELTING POINT: NOT ESTABLISHED.
SECTION X: STABILITY AND REACTIVITY

STABILITY: STABLE.

CONDITIONS TO AVOID: NONE KNOWN.

HAZARDOUS POLYMERIZATION: WILL NOT OCCUR.

INCOMPATIBLE MATERIALS: NONE KNOWN.

HAZARDOUS DECOMPOSITION PRODUCTS: BURNING WILL PRODUCE OXIDES OF CARBON, NITROGEN AND SULFUR.

SECTION XI: TOXICOLOGICAL PROPERTIES

RAT, ORAL LD50: GREATER THAN 5000 MG/KG.
RABBIT, SKIN: NON-IRRITATING.
RABBIT, EYES: IRRITATING.

ADDITIONAL TOXICITY DATA:

IN CONCLUSIVE MUTAGENICITY DATA HAS BEEN OBTAINED FOR THIS MATERIAL.

IARC

THIS MATERIAL HAS BEEN TESTED ONLY IN RATS BY ORAL AND SUBCUTANEOUS ADMINISTRATION, AND HAS BEEN ADMINISTERED TO RATS BY SUBCUTANEOUS INJECTION; THE DATA ARE INSUFFICIENT FOR AN EVALUATION OF CARCINOGENICITY OF THESE COMPOUNDS TO BE MADE.

SECTION XII: ECOLOGICAL INFORMATION

NO INFORMATION IS CURRENTLY AVAILABLE.

SECTION XIII: DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD: THIS PRODUCT IS NOT TO BE CONSIDERED A HAZARDOUS WASTE UNDER RCRA (40 CFR 261). DISPOSAL MUST BE IN ACCORDANCE WITH APPLICABLE GOVERNMENTAL REGULATIONS.

CONTAINER DISPOSAL INFORMATION: CONTAINERS SHOULD BE TRIPLE RINSED ACCORDING TO FEDERAL REGULATIONS AND/OR GOOD WASTE MANAGEMENT PRACTICE.

SECTION XIV: TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME: NOT REGULATED.
DOT TECHNICAL NAME: NOT APPLICABLE.
DOT HAZARD CLASS: NOT APPLICABLE.
HAZARD SUBCLASS: NOT APPLICABLE.
DOT UN/NA NUMBER: NOT APPLICABLE.
Packing Group: NOT APPLICABLE.
RESP. GUIDE PAGE: NOT APPLICABLE.
DOT REPORTABLE QUANTITY: NOT APPLICABLE.
DOT LABELS: NOT APPLICABLE.

SECTION XV: REGULATORY INFORMATION

SARA TITLE III SECTION 302: THIS PRODUCT DOES NOT CONTAIN ANY CHEMICALS REGULATED UNDER SECTION 302 AS EXTREMELY HAZARDOUS.

SARA TITLE III SECTION 304 (CERCLA): THIS PRODUCT DOES NOT CONTAIN ANY CHEMICALS REGULATED UNDER SECTION 304 AS A HAZARDOUS SUBSTANCE FOR EMERGENCY RELEASE NOTIFICATION.
SARA TITLE III SECTION 312 HAZARD RATING:
   ACUTE: YES
   CHRONIC: NO
   FLAMMABILITY: NO
   REACTIVITY: NO
   PRESSURE: NO

SARA TITLE III SECTION 313: THIS PRODUCT IS NOT REPORTABLE FOR SARA 313.

TSCA: THIS PRODUCT IS REGISTERED UNDER THE REGULATIONS OF THE TOXIC SUBSTANCES CONTROL ACT (TSCA).

STATE RIGHT TO KNOW INFORMATION
INGREDIENT
PROPRIETARY XANTHENE DYE
CAS NUMBER
NJTSRN-201841177-02-0160

SECTION XVI: OTHER INFORMATION

HMIS RATING: HEALTH - 2
   FIRE - 1
   REACTIVITY - 0
   PERSONAL PROTECTION - E

NFPA RATING: HEALTH - 2
   FIRE - 1
   REACTIVITY - 0

DISCLAIMER: GREENVILLE COLORANTS, L.L.C. BELIEVES ALL THE INFORMATION AND DATA GIVEN IS ACCURATE AS OF THE DATE OF PREPARATION AND IS OFFERED IN GOOD FAITH. THIS INFORMATION IS GIVEN WITHOUT WARRANTY OR REPRESENTATION SOLELY FOR YOUR CONSIDERATION, INVESTIGATION, AND VERIFICATION. SINCE CONDITIONS OF USE ARE BEYOND OUR CONTROL, GREENVILLE COLORANTS, L.L.C. EXPRESSLY DISCLAIMS ALL LIABILITY FOR THE USE OR HANDLING OF THIS PRODUCT.
FL MSD
MATERIAL SAFETY DATA SHEET
ORGANIC DYES AND PIGMENTS LLC.
65 VALLEY STREET
East Providence, Rhode Island 02914-0258
Telephone No. (401) 434-3300

Trade Name...: ORCOACID FLUORESCIENCE CRUDE 86%
Chemical Name: XANTHENE DYE
Synonyms......: ACID YELLOW DYE

Product No: 31073OR1E1

1. HAZARDOUS INGREDIENTS

WARNING! MAY FORM COMBUSTIBLE DUST CONCENTRATIONS IN THE AIR.

Warning.: OVEREXPOSURE TO THIS PRODUCT MAY CAUSE SLIGHT IRRITATION OF EYES AND SKIN.

2. PHYSICAL DATA

Appearance.........: DEEP AMBER POWDER.
Odor...............: SLIGHTLY AROMATIC.
Solubility in Water: SOLUBLE.

3. FIRE AND EXPLOSION HAZARD DATA

Flash Point and Method..........: N.A.
Flammable Limits
LEL: N.A.                  UEL: N.A.
Extinguishing Media.............: WATER SPRAY, DRY CHEMICALS, FOAM OR CARBON DIOXIDE.

Special Fire Fighting Procedures.: FIREFIGHTERS SHOULD WEAR FULL-FACE, SELF-
CONTAINED BREATHING APPARATUS AND IMPERVIOUS PROTECTIVE CLOTHING.

Unusual Fire and Explosion Hazards: NONE EXPECTED, BUT AVOID THE BUILD UP OF
DYE DUST CLOUDS WHICH COULD BE EXPLOSIVE, AS OTHER ORGANIC POWDERS ARE.

NFPA Fire Hazards Code

<table>
<thead>
<tr>
<th>Health</th>
<th>Fire</th>
<th>Reactivity</th>
<th>Specific</th>
<th>Minimal</th>
<th>Slight</th>
<th>Moderate</th>
<th>Serious</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>N.A.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Page 1 of 4
4. HEALTH HAZARD DATA

LD50 Oral (Ingestion).....: 4738 MG/KG (MOUSE)  6721 MG/KG (RAT)
LD50 Dermal (Skin Contact): N.E.
LC50 (Inhalation).........: N.E.
Primary Route of Exposure: N.E.
Threshold Limit Value.....: N.E.

Effects of Overexposure
Acute: SLIGHT IRRITATION OF EYES AND/OR SKIN.

Chronic: NO CHRONIC ILL EFFECTS KNOWN.

5. EMERGENCY AND FIRST AID PROCEDURES

Eyes........: IMMEDIATELY AND CONTINUOUS IRRIGATION WITH FLOWING WATER FOR AT LEAST FIFTEEN MINUTES. CONSULT PHYSICIAN IF IRRITATION OCCURS.
Skin.......: IMMEDIATELY FLUSH SKIN WITH PLENTY OF WATER. WASH WELL WITH SOAP AND WATER. LAUNDER CONTAMINATED CLOTHING BEFORE REUSE.
Ingestion.: IF CONSCIOUS, GIVE TWO GLASSES OF WATER TO DILUTE. INDUCE VOMITING ONLY IF ADVISED BY POISON CONTROL CENTER.
Inhalation: REMOVE TO FRESH AIR. IF EFFECTS OCCUR, CONSULT PHYSICIAN.

6. PHYSICAL HAZARDS

Precautions: MAINTAIN GOOD HOUSEKEEPING TO AVOID DUST BUILD UP. AVOID INGESTION, EYE AND SKIN CONTACT. MINIMIZE INHALATION EXPOSURE BY USING DUST RESPIRATOR. WASH HANDS AFTER WEIGHING DYE TO AVOID CONTACT OF THE SKIN OR EYES WITH CONTAMINATED HANDS. A SENSITIZED INDIVIDUAL SHOULD NOT BE EXPOSED TO THE PRODUCT WHICH CAUSED THE SENSITIZATION.

7. SPECIAL PROTECTION INFORMATION

Ventilation.......: USE LOCAL EXHAUST VENTILATION TO MINIMIZE EXPOSURE.
Respiratory......: A NIOSH/MSHA APPROVED DUST RESPIRATOR SHOULD BE WORN.
Eye Protection....: WEAR SIDE-SHIELD SAFETY GLASSES OR CHEMICAL SAFETY GOGGLES.
Protective Gloves: WEAR IMPERVIOUS GLOVES AS A STANDARD HANDLING PROCEDURE. OTHER............: DELUGE SAFETY SHOWER, EYE WASH STATION, PROTECTIVE CLOTHING.

All chemicals should be handled so as to prevent eye contact and excessive or repeated skin contact. Appropriate eye and skin protection should be employed. Inhalation of dusts and vapors should be avoided.

8. CHEMICAL REACTIVITY

Stability......................: STABLE UNDER NORMAL STORAGE CONDITIONS.

Incompatibility (Materials to Avoid): OXIDIZING AND REDUCING AGENTS.

Hazardous Decomposition Products....: BURNING WILL PRODUCE OXIDES OF CARBON, NITROGEN AND SULFUR.

Hazardous Polymerization............: WILL NOT OCCUR UNDER NORMAL CONDITIONS.

9. STORAGE INFORMATION

Precautions To Be Taken In Handling And Storing: AVOID BREATHING DUST. AVOID CONTACT WITH EYES AND SKIN; WASH THOROUGHLY AFTER HANDLING. STORE IN A DRY PLACE AWAY FROM EXCESSIVE HEAT, IN ORIGINAL OR SIMILAR WATERPROOF CONTAINERS. RESEAL CONTAINERS IMMEDIATELY AFTER USE.

10. SPILL, LEAK AND DISPOSAL INFORMATION

Accidental Release Measures: UTILIZE RECOMMENDED PROTECTIVE CLOTHING AND RESPIRATORY PROTECTION. MIX MATERIAL WITH SWEEPING COMPOUND TO MINIMIZE DUSTING WHILE SWEEPING UP AND CONTAINING. VACUUM CONTAMINATED AREA.

Disposal Considerations....: DISPOSE OF IN ACCORDANCE WITH LOCAL, STATE AND FEDERAL ENVIRONMENTAL CONTROL REGULATIONS. EMPTY CONTAINERS RETAIN PRODUCT RESIDUE AND SHOULD NOT BE DISTRIBUTED, MADE AVAILABLE, FURNISHED OR REUSED...
11. SHIPPING INFORMATION

DOT Shipping Name: NOT REGULATED.
Technical Shipping Name: NOT APPLICABLE.

DOT Hazard Classification
Primary: NOT APPLICABLE.
Secondary: NOT APPLICABLE.

Freight Classification: NOT REGULATED.

UN Number: NOT APPLICABLE.

IMO Hazard Class: NOT APPLICABLE.

DOT Labels Required: COMMUNITY RIGHT TO KNOW LABEL.

EPA/DOT Hazardous Substances Rq: NOT APPLICABLE.

12. OTHER GOVERNMENT REGULATIONS

TSCA: ALL COMPONENTS OF THIS PRODUCT ARE IN COMPLIANCE WITH THE TOXIC SUBSTANCE CONTROL ACT.

13. ADDITIONAL COMMENTS

Practices: HANDLE WITH DUE CARE AND MINIMIZE EXPOSURE IN ACCORDANCE WITH GOOD INDUSTRIAL HYGIENE PRACTICE.

DISCLAIMER

Information contained herein is, to our best knowledge, true and accurate. It is offered for information only, as we cannot guarantee the results of processes not under our direct control.
SAFETY DATA SHEET

1. Identification

Product identifier: Potassium iodide

Other means of identification
Product No.: 1112, 3164, 3162, 1127, 1123, 1115

Recommended use and restriction on use
Recommended use: Not available.
Restrictions on use: Not known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer
Company Name: Avantor Performance Materials, Inc.
Address: 3477 Corporate Parkway, Suite 200
Center Valley, PA 18034
Telephone: Customer Service: 855-282-6867
Fax: 24 Hour Emergency: 908-859-2151
Contact Person: Environmental Health & Safety
e-mail: info@avantormaterials.com

Emergency telephone number:
Chemtrec: 800-424-9300

2. Hazard(s) identification

Hazard classification

Health hazards
Skin corrosion/irritation  Category 2
Serious eye damage/eye irritation  Category 2B
Toxic to reproduction  Category 2
Specific target organ toxicity - single exposure  Category 3
Specific target organ toxicity - repeated exposure  Category 1

Label elements

Hazard symbol:

Signal word: Danger

Hazard statement: Causes skin irritation.
Causes eye irritation.
May cause respiratory irritation.
Suspected of damaging the unborn child.
Causes damage to organs through prolonged or repeated exposure.
Precautionary statement

Prevention: Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Do not breathe dust/fume/gas/mist/vapors/spray. Wash thoroughly after handling. Do not eat, drink or smoke when using this product. Use only outdoors or in a well-ventilated area. Wear protective gloves/protective clothing/eye protection/face protection.

Response: IF exposed or concerned: Get medical advice/attention. IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/physician if you feel unwell. IF ON SKIN: Wash with plenty of soap and water. If skin irritation occurs: Get medical advice/attention. Take off contaminated clothing and wash before reuse. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.

Storage: Store in a well-ventilated place. Keep container tightly closed. Store locked up.

Disposal: Dispose of contents/container to an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal.

Other hazards which do not result in GHS classification: None.

3. Composition/information on ingredients

<table>
<thead>
<tr>
<th>Chemical identity</th>
<th>Common name and synonyms</th>
<th>CAS number</th>
<th>Content in percent (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>POTASSIUM IODIDE</td>
<td></td>
<td>7681-11-0</td>
<td>99 - 100%</td>
</tr>
</tbody>
</table>

* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

4. First-aid measures

General information: Ensure that emergency personnel are aware of the material involved, and take precautions to protect themselves.

Ingestion: Rinse mouth. Call a POISON CENTER or doctor/physician if you feel unwell.

Inhalation: Move to fresh air. Call a POISON CENTER or doctor/physician if you feel unwell.

Skin contact: Wash the skin immediately with soap and water. Get medical attention if irritation persists after washing. Wash contaminated clothing before reuse.

Eye contact: Immediately flush with plenty of water for at least 15 minutes. If easy to do, remove contact lenses. Get medical attention if irritation persists after washing. In case of irritation from airborne exposure, move to fresh air.

Most important symptoms/effects, acute and delayed

Symptoms: Irritating to eyes, respiratory system and skin.
Indication of immediate medical attention and special treatment needed

Treatment: Treat symptomatically. Symptoms may be delayed.

5. Fire-fighting measures

General fire hazards: No unusual fire or explosion hazards noted.

Suitable (and unsuitable) extinguishing media

| Suitable extinguishing media: | Use fire-extinguishing media appropriate for surrounding materials. |
| Unsuitable extinguishing media: | None known. |

Specific hazards arising from the chemical: During fire, gases hazardous to health may be formed.

Special protective equipment and precautions for firefighters

| Special fire fighting procedures: | In case of fire and/or explosion do not breathe fumes. Move containers from fire area if you can do so without risk. Use water spray to keep fire-exposed containers cool. |
| Special protective equipment for fire-fighters: | Self-contained breathing apparatus and full protective clothing must be worn in case of fire. |

6. Accidental release measures

| Personal precautions, protective equipment and emergency procedures: | See Section 8 of the MSDS for Personal Protective Equipment. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Keep unauthorized personnel away. |
| Methods and material for containment and cleaning up: | Absorb spill with vermiculite or other inert material, then place in a container for chemical waste. Dike far ahead of larger spill for later recovery and disposal. |
| Notification Procedures: | Stop the flow of material, if this is without risk. Dike for later disposal. Prevent entry into waterways, sewer, basements or confined areas. Inform authorities if large amounts are involved. |
| Environmental precautions: | Do not contaminate water sources or sewer. Prevent further leakage or spillage if safe to do so. |

7. Handling and storage

| Precautions for safe handling: | Do not handle until all safety precautions have been read and understood. Obtain special instructions before use. Use personal protective equipment as required. Avoid contact with eyes, skin, and clothing. Avoid inhalation of dust. Do not taste or swallow. Wash hands thoroughly after handling. |
| Conditions for safe storage, including any incompatibilities: | Keep away from food, drink and animal feeding stuffs. Store in tightly closed original container in a dry, cool and well-ventilated place. |
8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

<table>
<thead>
<tr>
<th>Chemical identity</th>
<th>Type</th>
<th>Exposure Limit values</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>POTASSIUM IODIDE - Inhalable fraction and vapor.</td>
<td>TWA</td>
<td>0.01 ppm</td>
<td>US. ACGIH Threshold Limit Values (2011)</td>
</tr>
<tr>
<td>POTASSIUM IODIDE - Particulate.</td>
<td>ST ESL</td>
<td>50 µg/m³</td>
<td>US. Texas. Effects Screening Levels (Texas Commission on Environmental Quality) (12 2010)</td>
</tr>
<tr>
<td></td>
<td>AN ESL</td>
<td>5 µg/m³</td>
<td>US. Texas. Effects Screening Levels (Texas Commission on Environmental Quality) (12 2010)</td>
</tr>
</tbody>
</table>

Appropriate engineering controls

Adequate ventilation should be provided so that exposure limits are not exceeded.

Individual protection measures, such as personal protective equipment

General information: Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. An eye wash and safety shower must be available in the immediate work area.

Eye/face protection: Wear safety glasses with side shields (or goggles).

Skin protection
Hand protection: Wear protective gloves.

Other: Wear suitable protective clothing.

Respiratory protection: If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn.

Hygiene measures: Provide eyewash station and safety shower. Do not eat, drink or smoke when using the product. Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants. Wash contaminated clothing before reuse.

9. Physical and chemical properties

Appearance

Physical state: Solid
Form: Granules or powder
Color: Colorless or white
Odor: No data available.
Odor threshold: No data available.
ph: 7 - 9 Aqueous solution is neutral or usually slightly alkaline.
Melting point/freezing point: 681 °C
Initial boiling point and boiling range: 1,323 °C
Flash Point: No data available.
Evaporation rate: No data available.
Flammability (solid, gas): No data available.
### Upper/lower limit on flammability or explosive limits

| Flammability limit - upper (%) | No data available. |
| Flammability limit - lower (%) | No data available. |
| Explosive limit - upper (%)   | No data available. |
| Explosive limit - lower (%)   | No data available. |

Vapor pressure: Estimated < 0.0000001 kPa (25 °C)

Vapor density: No data available.

Relative density: 3.13

Solubility(ies)

| Solubility in water: | 1.43 g/l |
| Solubility (other):  | No data available. |

Partition coefficient (n-octanol/water): No data available.

Auto-ignition temperature: No data available.

Decomposition temperature: No data available.

Viscosity: No data available.

### Other information

Molecular weight: 166.02 g/mol (IK)

### 10. Stability and reactivity

**Reactivity:** No dangerous reaction known under conditions of normal use.

**Chemical stability:** Material is stable under normal conditions.

**Possibility of hazardous reactions:** Hazardous polymerization does not occur.

**Conditions to avoid:** Exposure to air. Moisture. Light.

**Incompatible materials:** Strong oxidizing agents. Chlorinated compounds. Inorganic salts. Acids.

**Hazardous decomposition products:** Halogens. Oxides of potassium.

### 11. Toxicological information

**Information on likely routes of exposure**

| Ingestion:                  | May cause irritation of the gastrointestinal tract. |
| Inhilation:                | May cause irritation to the respiratory system.    |
| Skin contact:              | Causes skin irritation.                             |
| Eye contact:               | Causes eye irritation.                              |

**Information on toxicological effects**

**Acute toxicity (list all possible routes of exposure)**

| Oral Product: | No data available. |
| Dermal Product: | No data available. |
| Inhalation Product: | No data available. |
Repeated dose toxicity
Product: No data available.

Skin corrosion/irritation
Product: Causes skin irritation.

Serious eye damage/eye irritation
Product: Causes eye irritation.

Respiratory or skin sensitization
Product: Not a skin sensitizer.

Carcinogenicity
Product: This substance has no evidence of carcinogenic properties.

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans:
No carcinogenic components identified

US. National Toxicology Program (NTP) Report on Carcinogens:
No carcinogenic components identified

No carcinogenic components identified

Germ cell mutagenicity

In vitro
Product: No mutagenic components identified

In vivo
Product: No mutagenic components identified

Reproductive toxicity
Product: May damage fertility or the unborn child.

Specific target organ toxicity - single exposure
Product: Respiratory tract irritation.

Specific target organ toxicity - repeated exposure
Product: Thyroid - Causes damage to organs through prolonged or repeated exposure.

Aspiration hazard
Product: Not classified

Other effects: None known.

12. Ecological information

Ecotoxicity:

Acute hazards to the aquatic environment:

Fish
Product: No data available.

Specified substance(s):
POTASSIUM IODIDE
LC 50 (Rainbow trout,donaldson trout (Oncorhynchus mykiss), 96 h): 896 mg/l Mortality

Aquatic invertebrates
Product: No data available.

Specified substance(s):
POTASSIUM IODIDE LC 50 (Zebra mussel (Dreissena polymorpha), 24 h): 220 - 313 mg/l Mortality

**Chronic hazards to the aquatic environment:**

- **Fish**
- **Product:** No data available.

- **Aquatic invertebrates**
- **Product:** No data available.

- **Toxicity to Aquatic Plants**
- **Product:** No data available.

**Persistence and degradability**

- **Biodegradation**
- **Product:** There are no data on the degradability of this product.

- **BOD/COD ratio**
- **Product:** No data available.

**Bioaccumulative potential**

- **Bioconcentration factor (BCF)**
- **Product:** No data available on bioaccumulation.

- **Partition coefficient n-octanol / water (log Kow)**
- **Product:** No data available.

**Mobility in soil:**

- **No data available.**

**Known or predicted distribution to environmental compartments**

- **POTASSIUM IODIDE**
- **No data available.**

**Other adverse effects:**

- The product components are not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.

13. **Disposal considerations**

- **Disposal instructions:** Discharge, treatment, or disposal may be subject to national, state, or local laws.

- **Contaminated packaging:** Since emptied containers retain product residue, follow label warnings even after container is emptied.

14. **Transport information**

- **DOT** Not regulated.

- **IMDG** Not regulated.

- **IATA** Not regulated.
15. Regulatory information

US federal regulations

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)
US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)
None present or none present in regulated quantities.

CERCLA Hazardous Substance List (40 CFR 302.4):
None present or none present in regulated quantities.

Superfund amendments and reauthorization act of 1986 (SARA)

Hazard categories

- Acute (Immediate)
- Chronic (Delayed)
- Fire
- Reactive
- Pressure Generating

SARA 302 Extremely hazardous substance
None present or none present in regulated quantities.

SARA 304 Emergency release notification
None present or none present in regulated quantities.

SARA 311/312 Hazardous chemical

<table>
<thead>
<tr>
<th>Chemical identity</th>
<th>Threshold Planning Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>POTASSIUM IODIDE</td>
<td>500 lbs</td>
</tr>
</tbody>
</table>

SARA 313 (TRI reporting)
None present or none present in regulated quantities.

Clean Water Act Section 311 Hazardous Substances (40 CFR 117.3)
None present or none present in regulated quantities.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130):
None present or none present in regulated quantities.

US state regulations

US. California Proposition 65
No ingredient regulated by CA Prop 65 present.

US. New Jersey Worker and Community Right-to-Know Act
No ingredient regulated by NJ Right-to-Know Law present.

US. Massachusetts RTK - Substance List
No ingredient regulated by MA Right-to-Know Law present.

US. Pennsylvania RTK - Hazardous Substances
No ingredient regulated by PA Right-to-Know Law present.

US. Rhode Island RTK
No ingredient regulated by RI Right-to-Know Law present.
Inventory Status:
- Australia AICS: On or in compliance with the inventory
- Canada DSL Inventory List: On or in compliance with the inventory
- EU EINECS List: On or in compliance with the inventory
- EU ELINCS List: Not in compliance with the inventory.
- Japan (ENCS) List: Not in compliance with the inventory.
- EU No Longer Polymers List: Not in compliance with the inventory.
- China Inv. Existing Chemical Substances: On or in compliance with the inventory
- Korea Existing Chemicals Inv. (KECI): On or in compliance with the inventory
- Canada NDSL Inventory: Not in compliance with the inventory.
- Philippines PICCS: On or in compliance with the inventory
- US TSCA Inventory: On or in compliance with the inventory
- New Zealand Inventory of Chemicals: On or in compliance with the inventory
- Japan ISHL Listing: On or in compliance with the inventory
- Japan Pharmacopoeia Listing: Not in compliance with the inventory.

16. Other information, including date of preparation or last revision

NFPA Hazard ID

<table>
<thead>
<tr>
<th>Flammability</th>
<th>Health</th>
<th>Reactivity</th>
<th>Special hazard.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe

Issue date: 03-06-2014
Revision date: No data available.
Version #: 1.0
Further information: No data available.
Disclaimer:

THE INFORMATION PRESENTED IN THIS MATERIAL SAFETY DATA SHEET (MSDS/SDS) WAS PREPARED BY TECHNICAL PERSONNEL BASED ON DATA THAT THEY BELIEVE IN THEIR GOOD FAITH JUDGMENT IS ACCURATE. HOWEVER, THE INFORMATION PROVIDED HEREIN IS PROVIDED "AS IS," AND AVANTOR PERFORMANCE MATERIALS MAKES AND GIVES NO REPRESENTATIONS OR WARRANTIES WHATSOEVER, AND EXPRESSLY DISCLAIMS ALL WARRANTIES REGARDING SUCH INFORMATION AND THE PRODUCT TO WHICH IT RELATES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING WITHOUT LIMITATION, WARRANTIES OF ACCURACY, COMPLETENESS, MERCHANTABILITY, NON-INFRINGEMENT, PERFORMANCE, SAFETY, SUITABILITY, STABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTIES ARISING FROM COURSE OF DEALING, COURSE OF PERFORMANCE, OR USAGE OF TRADE. THIS MSDS/SDS IS INTENDED ONLY AS A GUIDE TO THE APPROPRIATE PRECAUTIONARY HANDLING OF THE MATERIAL BY A PROPERLY TRAINED PERSON USING THIS PRODUCT, AND IS NOT INTENDED TO BE COMPREHENSIVE AS TO THE MANNER AND CONDITIONS OF USE, HANDLING, STORAGE, OR DISPOSAL OF THE PRODUCT. INDIVIDUALS RECEIVING THIS MSDS/SDS MUST ALWAYS EXERCISE THEIR OWN INDEPENDENT JUDGMENT IN DETERMINING THE APPROPRIATENESS OF SUCH ISSUES. ACCORDINGLY, AVANTOR PERFORMANCE MATERIALS ASSUMES NO LIABILITY WHATSOEVER FOR THE USE OF OR RELIANCE UPON THIS INFORMATION. NO SUGGESTIONS FOR USE ARE INTENDED AS, AND NOTHING HEREIN SHALL BE CONSTRUED AS, A RECOMMENDATION TO INFRINGE ANY EXISTING PATENTS OR TO VIOLATE ANY FEDERAL, STATE, LOCAL, OR FOREIGN LAWS. AVANTOR PERFORMANCE MATERIALS REMINDS YOU THAT IT IS YOUR LEGAL DUTY TO MAKE ALL INFORMATION IN THIS MSDS/SDS AVAILABLE TO YOUR EMPLOYEES.
SAFETY DATA SHEET

1. Identification

Product identifier: SODIUM IODIDE

Other means of identification
Product No.: 3748, 1141

Recommended use and restriction on use
Recommended use: Not available.
Restrictions on use: Not known.

Details of the supplier of the safety data sheet

Manufacturer
Company Name: Avantor Performance Materials, Inc.
Address: 3477 Corporate Parkway, Suite 200
Center Valley, PA 18034
Telephone: Customer Service: 855-282-6867
Fax: Contact Person: Environmental Health & Safety
E-mail: info@avantormaterials.com

Emergency telephone number:
24 Hour Emergency: 908-859-2151
Chemtrec: 800-424-9300

2. Hazard(s) identification

Hazard Classification

Health Hazards
Skin Corrosion/Irritation Category 2
Serious Eye Damage/Eye irritation Category 2

Environmental Hazards
Acute hazards to the aquatic environment Category 1

Label Elements

Hazard Symbol:

Signal Word: Warning

Hazard Statement:
Causes skin irritation.
Causes serious eye irritation.
Very toxic to aquatic life.

Precautionary Statement

SDS_US - SDS000000945 1/10
Prevention: Wear protective gloves/protective clothing/eye protection/face protection. Wash thoroughly after handling. Avoid release to the environment.

Response: IF ON SKIN: Wash with plenty of soap and water. If skin irritation occurs: Take off contaminated clothing. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention. Collect spillage.

Other hazards which do not result in GHS classification: None.

3. Composition/information on ingredients

Substances

<table>
<thead>
<tr>
<th>Chemical Identity</th>
<th>Common name and synonyms</th>
<th>CAS number</th>
<th>Content in percent (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SODIUM IODIDE</td>
<td></td>
<td>7681-82-5</td>
<td>90 - 100%</td>
</tr>
</tbody>
</table>

* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

4. First-aid measures

General information: Get medical advice/attention if you feel unwell. Show this safety data sheet to the doctor in attendance.

Ingestion: Rinse mouth thoroughly. Call a POISON CENTER or doctor/physician if you feel unwell.

Inhalation: Move to fresh air. Get medical attention if symptoms persist.

Skin Contact: Wash skin thoroughly with soap and water. Get medical attention if irritation persists after washing. Wash contaminated clothing before reuse.

Eye contact: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.

Most important symptoms/effects, acute and delayed

Symptoms: Irritating to eyes, respiratory system and skin.

Indication of immediate medical attention and special treatment needed

Treatment: Treat symptomatically. Symptoms may be delayed.

5. Fire-fighting measures

General Fire Hazards: No unusual fire or explosion hazards noted.

Suitable (and unsuitable) extinguishing media

Suitable extinguishing media: Use fire-extinguishing media appropriate for surrounding materials.

Unsuitable extinguishing media: None known.
Specific hazards arising from the chemical:
During fire, gases hazardous to health may be formed.

Special protective equipment and precautions for firefighters

Special fire fighting procedures:
Move containers from fire area if you can do so without risk. Use water spray to keep fire-exposed containers cool. Cool containers exposed to flames with water until well after the fire is out.

Special protective equipment for fire-fighters:
Firefighters must use standard protective equipment including flame retardant coat, helmet with face shield, gloves, rubber boots, and in enclosed spaces, SCBA.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures:
Keep unauthorized personnel away. Use personal protective equipment. Ventilate closed spaces before entering them. See Section 8 of the SDS for Personal Protective Equipment.

Methods and material for containment and cleaning up:
Sweep up and place in a clearly labeled container for chemical waste. Clean surface thoroughly to remove residual contamination.

Notification Procedures:
Prevent entry into waterways, sewer, basements or confined areas. Stop leak if you can do so without risk. Inform authorities if large amounts are involved.

Environmental Precautions:
Prevent further leakage or spillage if safe to do so. Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling:
Use personal protective equipment as required. Avoid contact with eyes, skin, and clothing. Avoid inhalation of dust. Wash thoroughly after handling.

Conditions for safe storage, including any incompatibilities:
Keep container tightly closed. Store in a cool and well-ventilated place. Store in a dry place. Store away from incompatible materials.

8. Exposure controls/personal protection

Control Parameters

Occupational Exposure Limits

<table>
<thead>
<tr>
<th>Chemical Identity</th>
<th>type</th>
<th>Exposure Limit Values</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SODIUM IODIDE - Inhalable fraction and vapor.</td>
<td>TWA</td>
<td>0.01 ppm</td>
<td>US. ACGIH Threshold Limit Values (2011)</td>
</tr>
</tbody>
</table>

Appropriate Engineering Controls

Individual protection measures, such as personal protective equipment

General information:
Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. An eye wash and safety shower must be available in the immediate work area.

Eye/face protection:
Chemical goggles and face shield are recommended.
9. Physical and chemical properties

**Appearance**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical state:</td>
<td>solid</td>
</tr>
<tr>
<td>Form:</td>
<td>Crystals or powder</td>
</tr>
<tr>
<td>Color:</td>
<td>White</td>
</tr>
<tr>
<td>Odor:</td>
<td>Odorless</td>
</tr>
<tr>
<td>Odor threshold:</td>
<td>No data available</td>
</tr>
<tr>
<td>pH:</td>
<td>6 - 9% aqueous solution</td>
</tr>
<tr>
<td>Melting point/freezing point:</td>
<td>661 °C</td>
</tr>
<tr>
<td>Initial boiling point and boiling range:</td>
<td>1,304 °C</td>
</tr>
<tr>
<td>Flash Point:</td>
<td>not applicable</td>
</tr>
<tr>
<td>Evaporation rate:</td>
<td>No data available</td>
</tr>
<tr>
<td>Flammability (solid, gas):</td>
<td>No data available</td>
</tr>
<tr>
<td>Upper/lower limit on flammability or explosive limits:</td>
<td></td>
</tr>
<tr>
<td>Flammability limit - upper (%)</td>
<td>No data available</td>
</tr>
<tr>
<td>Flammability limit - lower (%)</td>
<td>No data available</td>
</tr>
<tr>
<td>Explosive limit - upper (%)</td>
<td>No data available</td>
</tr>
<tr>
<td>Explosive limit - lower (%)</td>
<td>No data available</td>
</tr>
<tr>
<td>Vapor pressure:</td>
<td>0.13 kPa (767 °C)</td>
</tr>
<tr>
<td>Vapor density:</td>
<td>No data available</td>
</tr>
<tr>
<td>Relative density:</td>
<td>3.67 (20 °C)</td>
</tr>
<tr>
<td>Solubility(ies)</td>
<td></td>
</tr>
<tr>
<td>Solubility in water:</td>
<td>1,840 g/l (25 °C)</td>
</tr>
<tr>
<td>Solubility (other):</td>
<td>acetone: 399 g/l (25 °C)</td>
</tr>
<tr>
<td></td>
<td>alcohol: 4,257 g/l (25 °C)</td>
</tr>
<tr>
<td></td>
<td>glycerol: 1,000 g/l</td>
</tr>
<tr>
<td>Partition coefficient (n-octanol/water):</td>
<td>0.04</td>
</tr>
<tr>
<td>Auto-ignition temperature:</td>
<td>No data available</td>
</tr>
<tr>
<td>Decomposition temperature:</td>
<td>No data available</td>
</tr>
<tr>
<td>Viscosity:</td>
<td>No data available</td>
</tr>
<tr>
<td>Solubility (other):</td>
<td></td>
</tr>
</tbody>
</table>

10. Stability and reactivity

**Reactivity:** May react with strong oxidizers.
Chemical Stability: Material is stable under normal conditions.

Possibility of Hazardous Reactions: Hazardous polymerization does not occur.

Conditions to Avoid: Contact with incompatible materials. Light.


Hazardous Decomposition Products: Sodium oxides

11. Toxicological information

Information on likely routes of exposure
Ingestion: May cause irritation of the gastrointestinal tract.
Inhalation: Dust may irritate respiratory system or lungs.
Skin Contact: Causes skin irritation.
Eye contact: Causes serious eye irritation.

Information on toxicological effects
Acute toxicity (list all possible routes of exposure)
Oral Product: LD 50 (Rat): 4,340 mg/kg
Dermal Product: No data available.
Inhalation Product: No data available.
Repeated dose toxicity Product: No data available.
Skin Corrosion/Irritation Product: Causes skin irritation.
Serious Eye Damage/Eye Irritation Product: Causes serious eye irritation.
Respiratory or Skin Sensitization Product: Not a skin sensitizer.
Carcinogenicity Product: This substance has no evidence of carcinogenic properties.

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: No carcinogenic components identified
US. National Toxicology Program (NTP) Report on Carcinogens: No carcinogenic components identified
Germ Cell Mutagenicity

In vitro
Product: No mutagenic components identified

In vivo
Product: No mutagenic components identified

Reproductive toxicity
Product: No components toxic to reproduction

Specific Target Organ Toxicity - Single Exposure
Product: None known.

Specific Target Organ Toxicity - Repeated Exposure
Product: None known.

Aspiration Hazard
Product: Not classified

Other effects: None known.

12. Ecological information

Ecotoxicity:

Acute hazards to the aquatic environment:

Fish
Product: No data available.

Specified substance(s):
SODIUM IODIDE
LC 50 (Rainbow trout, donaldson trout (Oncorhynchus mykiss), 96 h): 1,900 - 4,200 mg/l Mortality

Aquatic Invertebrates
Product: No data available.

Specified substance(s):
SODIUM IODIDE
LC 50 (Water flea (Daphnia magna), 48 h): 0.1 - 0.3 mg/l Mortality

Chronic hazards to the aquatic environment:

Fish
Product: No data available.

Aquatic Invertebrates
Product: No data available.

Toxicity to Aquatic Plants
Product: No data available.

Persistence and Degradability

Biodegradation
Product: There are no data on the degradability of this product.

BOD/COD Ratio
Product: No data available.
Bioaccumulative Potential
Bioconcentration Factor (BCF)
Product: No data available on bioaccumulation.

Partition Coefficient n-octanol / water (log Kow)
Product: Log Kow: 0.04

Mobility in Soil: The product is water soluble and may spread in water systems.
Other Adverse Effects: Very toxic to aquatic life.

13. Disposal considerations

Disposal instructions: Discharge, treatment, or disposal may be subject to national, state, or local laws.
Contaminated Packaging: Since emptied containers retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT
UN Number: UN 3077
UN Proper Shipping Name: Environmentally hazardous substance, solid, n.o.s. (SODIUM IODIDE)
Transport Hazard Class(es): 9
Label(s): 9
Packing Group: III
Marine Pollutant: Yes
Special precautions for user: –

IMDG
UN Number: UN 3077
UN Proper Shipping Name: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (SODIUM IODIDE)
Transport Hazard Class(es): 9
Label(s): 9
EmS No.: F-A, S-F
Packing Group: III
Marine Pollutant: Yes
Special precautions for user: –

IATA
UN Number: UN 3077
Proper Shipping Name: Environmentally hazardous substance, solid, n.o.s. (SODIUM IODIDE)
Transport Hazard Class(es): 9
Label(s): 9
Marine Pollutant: Yes
Packing Group: III
Special precautions for user: –

15. Regulatory information

US Federal Regulations
TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)
US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)
None present or none present in regulated quantities.

CERCLA Hazardous Substance List (40 CFR 302.4):
None present or none present in regulated quantities.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories
Acute (Immediate)
Chronic (Delayed)

SARA 302 Extremely Hazardous Substance
None present or none present in regulated quantities.

SARA 304 Emergency Release Notification
None present or none present in regulated quantities.

SARA 311/312 Hazardous Chemical
<table>
<thead>
<tr>
<th>Chemical Identity</th>
<th>Threshold Planning Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SODIUM IODIDE</td>
<td>10000 lbs</td>
</tr>
</tbody>
</table>

SARA 313 (TRI Reporting)
None present or none present in regulated quantities.

Clean Water Act Section 311 Hazardous Substances (40 CFR 117.3)
None present or none present in regulated quantities.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130):
None present or none present in regulated quantities.

US State Regulations

US. California Proposition 65
No ingredient regulated by CA Prop 65 present.

US. New Jersey Worker and Community Right-to-Know Act
No ingredient regulated by NJ Right-to-Know Law present.

US. Massachusetts RTK - Substance List
No ingredient regulated by MA Right-to-Know Law present.

US. Pennsylvania RTK - Hazardous Substances
No ingredient regulated by PA Right-to-Know Law present.

US. Rhode Island RTK
No ingredient regulated by RI Right-to-Know Law present.
Inventory Status:

- Australia AICS: On or in compliance with the inventory
- Canada DSL Inventory List: On or in compliance with the inventory
- EINECS, ELINCS or NLP: On or in compliance with the inventory
- Japan (ENCS) List: On or in compliance with the inventory
- China Inv. Existing Chemical Substances: On or in compliance with the inventory
- Korea Existing Chemicals Inv. (KECI): On or in compliance with the inventory
- Canada NDSL Inventory: Not in compliance with the inventory.
- Philippines PICCS: On or in compliance with the inventory
- US TSCA Inventory: On or in compliance with the inventory
- New Zealand Inventory of Chemicals: On or in compliance with the inventory
- Japan ISHL Listing: On or in compliance with the inventory
- Japan Pharmacopoeia Listing: Not in compliance with the inventory.

| 16. Other information, including date of preparation or last revision |

NFPA Hazard ID

- Flammability
- Health
- Reactivity
- Special hazard.

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe; RNP - Rating not possible

Issue Date: 03-27-2015
Revision Date: No data available.
Version #: 1.0
Further Information: No data available.
Disclaimer:

THE INFORMATION PRESENTED IN THIS MATERIAL SAFETY DATA SHEET (MSDS/SDS) WAS PREPARED BY TECHNICAL PERSONNEL BASED ON DATA THAT THEY BELIEVE IN THEIR GOOD FAITH JUDGMENT IS ACCURATE. HOWEVER, THE INFORMATION PROVIDED HEREIN IS PROVIDED "AS IS," AND AVANTOR PERFORMANCE MATERIALS MAKES AND GIVES NO REPRESENTATIONS OR WARRANTIES WHATSOEVER, AND EXPRESSLY DISCLAIMS ALL WARRANTIES REGARDING SUCH INFORMATION AND THE PRODUCT TO WHICH IT RELATES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING WITHOUT LIMITATION, WARRANTIES OF ACCURACY, COMPLETENESS, MERCHANTABILITY, NON-INFRINGEMENT, PERFORMANCE, SAFETY, SUITABILITY, STABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTIES ARISING FROM COURSE OF DEALING, COURSE OF PERFORMANCE, OR USAGE OF TRADE. THIS MSDS/SDS IS INTENDED ONLY AS A GUIDE TO THE APPROPRIATE PRECAUTIONARY HANDLING OF THE MATERIAL BY A PROPERLY TRAINED PERSON USING THIS PRODUCT, AND IS NOT INTENDED TO BE COMPREHENSIVE AS TO THE MANNER AND CONDITIONS OF USE, HANDLING, STORAGE, OR DISPOSAL OF THE PRODUCT. INDIVIDUALS RECEIVING THIS MSDS/SDS MUST ALWAYS EXERCISE THEIR OWN INDEPENDENT JUDGMENT IN DETERMINING THE APPROPRIATENESS OF SUCH ISSUES. ACCORDINGLY, AVANTOR PERFORMANCE MATERIALS ASSUMES NO LIABILITY WHATSOEVER FOR THE USE OF OR RELIANCE UPON THIS INFORMATION. NO SUGGESTIONS FOR USE ARE INTENDED AS, AND NOTHING HEREFIN SHALL BE CONSTRUED AS, A RECOMMENDATION TO INFRINGE ANY EXISTING PATENTS OR TO VIOLATE ANY FEDERAL, STATE, LOCAL, OR FOREIGN LAWS. AVANTOR PERFORMANCE MATERIALS REMINDS YOU THAT IT IS YOUR LEGAL DUTY TO MAKE ALL INFORMATION IN THIS MSDS/SDS AVAILABLE TO YOUR EMPLOYEES.
SAFETY DATA SHEET

1. Identification

Product identifier: AMMONIUM PHOSPHATE DIBASIC

Other means of identification
Product No.: 0784

Recommended use and restriction on use
Recommended use: Not available.
Restrictions on use: Not known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer
Company Name: Avantor Performance Materials, Inc.
Address: 3477 Corporate Parkway, Suite 200
Center Valley, PA 18034
Telephone: Customer Service: 855-282-6867
Fax: Contact Person: Environmental Health & Safety
e-mail: info@avantormaterials.com

Emergency telephone number:
24 Hour Emergency: 908-859-2151
Chemtrec: 800-424-9300

2. Hazard(s) identification

Hazard classification

Health hazards
Skin corrosion/irritation Category 2
Serious eye damage/eye irritation Category 2A
Specific target organ toxicity - single exposure Category 3

Environmental hazards
Acute hazards to the aquatic environment Category 3

Label elements
Hazard symbol:

Signal word: Warning

Hazard statement:
Causes serious eye irritation.
Causes skin irritation.
May cause respiratory irritation.
May cause drowsiness or dizziness.
Harmful to aquatic life.
Precautionary statement

Prevention: Wash hands thoroughly after handling. Wear protective gloves/protective clothing/eye protection/face protection. Avoid breathing dust/fume/gas/mist/vapors/spray. Use only outdoors or in a well-ventilated area. Avoid release to the environment.

Response: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention. IF ON SKIN: Wash with plenty of soap and water. If skin irritation occurs: Get medical advice/attention. IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/physician if you feel unwell.

Storage: Store in a well-ventilated place. Keep container tightly closed. Store locked up.

Disposal: Dispose of contents/container to an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal.

Other hazards which do not result in GHS classification: None.

3. Composition/information on ingredients

<table>
<thead>
<tr>
<th>Chemical identity</th>
<th>Common name and synonyms</th>
<th>CAS number</th>
<th>Content in percent (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMMONIUM PHOSPHATE DIBASIC</td>
<td></td>
<td>7783-28-0</td>
<td>98 - 100%</td>
</tr>
</tbody>
</table>

* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

4. First-aid measures

General information: Get medical advice/attention if you feel unwell. Show this safety data sheet to the doctor in attendance.

Ingestion: Call a physician or poison control center immediately. Do not induce vomiting without advice from poison control center. If vomiting occurs, keep head low so that stomach content doesn’t get into the lungs.

Inhalation: Move to fresh air. Call a physician or poison control center immediately. If breathing stops, provide artificial respiration.

Skin contact: Immediately flush with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician or poison control center immediately. Wash contaminated clothing before reuse. Destroy or thoroughly clean contaminated shoes.

Eye contact: Immediately flush with plenty of water for at least 15 minutes. If easy to do, remove contact lenses. Get medical attention immediately.

Most important symptoms/effects, acute and delayed

Symptoms: Irritating to eyes, respiratory system and skin.
Indication of immediate medical attention and special treatment needed

Treatment: Treat symptomatically. Symptoms may be delayed.

5. Fire-fighting measures

General fire hazards: In case of fire and/or explosion do not breathe fumes.

Suitable (and unsuitable) extinguishing media

Suitable extinguishing media: Use fire-extinguishing media appropriate for surrounding materials.

Unsuitable extinguishing media: None known.

Specific hazards arising from the chemical: Contact with metals may evolve flammable hydrogen gas. Fire may produce irritating, corrosive and/or toxic gases.

Special protective equipment and precautions for firefighters

Special fire fighting procedures: Move containers from fire area if you can do so without risk. Use water spray to keep fire-exposed containers cool. Cool containers exposed to flames with water until well after the fire is out.

Special protective equipment for fire-fighters: Firefighters must use standard protective equipment including flame retardant coat, helmet with face shield, gloves, rubber boots, and in enclosed spaces, SCBA.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures: Keep unauthorized personnel away. Use personal protective equipment. See Section 8 of the MSDS for Personal Protective Equipment. Ventilate closed spaces before entering them. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.

Methods and material for containment and cleaning up: Sweep up and place in a clearly labeled container for chemical waste. Clean surface thoroughly to remove residual contamination. Dike far ahead of larger spill for later recovery and disposal.

Notification Procedures: Dike for later disposal. Prevent entry into waterways, sewer, basements or confined areas. Stop the flow of material, if this is without risk. Inform authorities if large amounts are involved.

Environmental precautions: Do not contaminate water sources or sewer. Prevent further leakage or spillage if safe to do so. Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling: Use personal protective equipment as required. Do not breathe mist or vapor. Do not taste or swallow. Do not eat, drink or smoke when using the product. Use only with adequate ventilation. Wash hands thoroughly after handling. See Section 8 of the MSDS for Personal Protective Equipment. Avoid contact with eyes. Avoid contact with skin.

Conditions for safe storage, including any incompatibilities: Do not store in metal containers. Store in a dry place. Store in a well-ventilated place. Store locked up. Keep container tightly closed.
8. Exposure controls/personal protection

Control parameters

Occupational exposure limits
None of the components have assigned exposure limits.

Appropriate engineering controls
No data available.

Individual protection measures, such as personal protective equipment

General information: Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. An eye wash and safety shower must be available in the immediate work area.

Eye/face protection: Wear safety glasses with side shields (or goggles) and a face shield.

Skin protection

Hand protection: Chemical resistant gloves

Other: Wear suitable protective clothing.

Respiratory protection: In case of inadequate ventilation use suitable respirator.

Hygiene measures: Provide eyewash station and safety shower. Observe good industrial hygiene practices. Wash hands before breaks and immediately after handling the product. Do not eat, drink or smoke when using the product. Wash contaminated clothing before reuse.

9. Physical and chemical properties

Appearance

Physical state: Solid
Form: Crystals or powder.
Color: White
Odor: Odorless
Odor threshold: No data available.

pH: Approximate 8
Melting point/freezing point: 155 °C Decomposes
Initial boiling point and boiling range: No data available.
Flash Point: No data available.
Evaporation rate: No data available.
Flammability (solid, gas): No data available.

Upper/lower limit on flammability or explosive limits

Flammability limit - upper (%): No data available.
Flammability limit - lower (%): No data available.
Explosive limit - upper (%): No data available.
Explosive limit - lower (%): No data available.

Vapor pressure: No data available.
Vapor density: No data available.
Relative density: 1.62 (20 °C)

Solubility(ies)

Solubility in water: 588 g/l
### Solubility (other):
No data available.

### Partition coefficient (n-octanol/water):
No data available.

### Auto-ignition temperature:
No data available.

### Decomposition temperature:
No data available.

### Viscosity:
No data available.

### Other information

#### Molecular weight:
132.06 g/mol (H3N.1/2H3O4P)

### 10. Stability and reactivity

#### Reactivity:
No dangerous reaction known under conditions of normal use.

#### Chemical stability:
Material is stable under normal conditions.

#### Possibility of hazardous reactions:
Hazardous polymerization does not occur.

#### Conditions to avoid:
Heat, sparks, flames. Contact with air. Contact with incompatible materials.

#### Incompatible materials:
Sodium hypochlorite.

#### Hazardous decomposition products:
ammonia oxides of phosphorus

### 11. Toxicological information

#### Information on likely routes of exposure

**Ingestion:**
May be harmful if swallowed. May cause irritation of the gastrointestinal tract.

**Inhalation:**
May be harmful if inhaled. May cause drowsiness or dizziness.

**Skin contact:**
Causes skin irritation.

**Eye contact:**
Causes serious eye irritation.

#### Information on toxicological effects

**Acute toxicity (list all possible routes of exposure)**

**Oral Product:**
No data available.

**Dermal Product:**
No data available.

**Inhalation Product:**
No data available.

**Repeated dose toxicity Product:**
No data available.

**Skin corrosion/irritation Product:**
Causes skin irritation.

**Serious eye damage/eye irritation Product:**
Causes serious eye irritation.

**Respiratory or skin sensitization Product:**
Not a skin sensitizer.
Carcinogenicity
Product: This substance has no evidence of carcinogenic properties.

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans:
No carcinogenic components identified

US. National Toxicology Program (NTP) Report on Carcinogens:
No carcinogenic components identified

No carcinogenic components identified

Germ cell mutagenicity
In vitro
Product: No mutagenic components identified

In vivo
Product: No mutagenic components identified

Reproductive toxicity
Product: No components toxic to reproduction

Specific target organ toxicity - single exposure
Product: Respiratory tract irritation.

Specific target organ toxicity - repeated exposure
Product: No data available.

Aspiration hazard
Product: Not classified

Other effects: None known.

12. Ecological information

Ecotoxicity:

Acute hazards to the aquatic environment:

Fish
Product: No data available.

Specified substance(s):
AMMONIUM
PHOSPHATE DIBASIC
LC 50 (Rainbow trout, donaldson trout (Oncorhynchus mykiss), 96 h): 252 mg/l Mortality
LC 50 (Fathead minnow (Pimephales promelas), 96 h): 33 mg/l Mortality

Aquatic invertebrates
Product: No data available.

Chronic hazards to the aquatic environment:

Fish
Product: No data available.

Aquatic invertebrates
Product: No data available.

Toxicity to Aquatic Plants
Product: No data available.
Persistence and degradability

Biodegradation
Product: There are no data on the degradability of this product.

BOD/COD ratio
Product: No data available.

Bioaccumulative potential
Bioconcentration factor (BCF)
Product: No data available on bioaccumulation.

Partition coefficient n-octanol / water (log Kow)
Product: No data available.

Mobility in soil:
The product is water soluble and may spread in water systems.

Other adverse effects:
Harmful to aquatic organisms.

13. Disposal considerations

Disposal instructions:
Discharge, treatment, or disposal may be subject to national, state, or local laws. Dispose of contents/container to an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal.

Contaminated packaging:
Since emptied containers retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT
Not regulated.

IMDG
Not regulated.

IATA
Not regulated.

15. Regulatory information

US federal regulations

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)
US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)
None present or none present in regulated quantities.

CERCLA Hazardous Substance List (40 CFR 302.4):
None present or none present in regulated quantities.

Superfund amendments and reauthorization act of 1986 (SARA)

Hazard categories

- [x] Acute (Immediate)
- [ ] Chronic (Delayed)
- [ ] Fire
- [ ] Reactive
- [ ] Pressure Generating
SARA 302 Extremely hazardous substance
None present or none present in regulated quantities.

SARA 304 Emergency release notification
None present or none present in regulated quantities.

SARA 311/312 Hazardous chemical

<table>
<thead>
<tr>
<th>Chemical identity</th>
<th>Threshold Planning Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMMONIUM</td>
<td>500 lbs</td>
</tr>
<tr>
<td>PHOSPHATE DIBASIC</td>
<td></td>
</tr>
</tbody>
</table>

SARA 313 (TRI reporting)

<table>
<thead>
<tr>
<th>Chemical identity</th>
<th>Reporting threshold for other users</th>
<th>Reporting threshold for manufacturing and processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMMONIUM</td>
<td>10000 lbs</td>
<td>25000 lbs.</td>
</tr>
<tr>
<td>PHOSPHATE DIBASIC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clean Water Act Section 311 Hazardous Substances (40 CFR 117.3)
None present or none present in regulated quantities.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130):
None present or none present in regulated quantities.

US state regulations

US. California Proposition 65
No ingredient regulated by CA Prop 65 present.

US. New Jersey Worker and Community Right-to-Know Act
No ingredient regulated by NJ Right-to-Know Law present.

US. Massachusetts RTK - Substance List
No ingredient regulated by MA Right-to-Know Law present.

US. Pennsylvania RTK - Hazardous Substances
No ingredient regulated by PA Right-to-Know Law present.

US. Rhode Island RTK
No ingredient regulated by RI Right-to-Know Law present.

Inventory Status:

| Australia AICS:                        | On or in compliance with the inventory |
| Canada DSL Inventory List:             | On or in compliance with the inventory |
| EINECS, ELINCS or NLP:                 | On or in compliance with the inventory |
| Japan (ENCS) List:                     | On or in compliance with the inventory |
| China Inv. Existing Chemical Substances:| Not in compliance with the inventory. |
| Korea Existing Chemicals Inv. (KECI): | On or in compliance with the inventory |
| Canada NDSL Inventory:                 | Not in compliance with the inventory. |
| Philippines PICCS:                     | On or in compliance with the inventory |
| US TSCA Inventory:                    | On or in compliance with the inventory |
| New Zealand Inventory of Chemicals:    | On or in compliance with the inventory |
| Japan ISHL Listing:                    | On or in compliance with the inventory |
| Japan Pharmacopoeia Listing:          | Not in compliance with the inventory. |

16. Other information, including date of preparation or last revision
NFPA Hazard ID

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe

Issue date: 08-21-2014
Revision date: No data available.
Version #: 1.0
Further information: No data available.

Disclaimer:
THE INFORMATION PRESENTED IN THIS MATERIAL SAFETY DATA SHEET (MSDS/SDS) WAS PREPARED BY TECHNICAL PERSONNEL BASED ON DATA THAT THEY BELIEVE IN THEIR GOOD FAITH JUDGMENT IS ACCURATE. HOWEVER, THE INFORMATION PROVIDED HEREIN IS PROVIDED "AS IS," AND AVANTOR PERFORMANCE MATERIALS MAKES AND GIVES NO REPRESENTATIONS OR WARRANTIES WHATSOEVER, AND EXPRESSLY DISCLAIMS ALL WARRANTIES REGARDING SUCH INFORMATION AND THE PRODUCT TO WHICH IT RELATES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING WITHOUT LIMITATION WARRANTIES OF ACCURACY, COMPLETENESS, MERCHANTABILITY, NON-INFRINGEMENT, PERFORMANCE, SAFETY, SUITABILITY, STABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTIES ARISING FROM COURSE OF DEALING, COURSE OF PERFORMANCE, OR USAGE OF TRADE. THIS MSDS/SDS IS INTENDED ONLY AS A GUIDE TO THE APPROPRIATE PRECAUTIONARY HANDLING OF THE MATERIAL BY A PROPERLY TRAINED PERSON USING THIS PRODUCT, AND IS NOT INTENDED TO BE COMPREHENSIVE AS TO THE MANNER AND CONDITIONS OF USE, HANDLING, STORAGE, OR DISPOSAL OF THE PRODUCT. INDIVIDUALS RECEIVING THIS MSDS/SDS MUST ALWAYS EXERCISE THEIR OWN INDEPENDENT JUDGMENT IN DETERMINING THE APPROPRIATENESS OF SUCH ISSUES. ACCORDINGLY, AVANTOR PERFORMANCE MATERIALS ASSUMES NO LIABILITY WHATSOEVER FOR THE USE OF OR RELIANCE UPON THIS INFORMATION. NO SUGGESTIONS FOR USE ARE INTENDED AS, AND NOTHING HEREIN SHALL BE CONSTRUED AS, A RECOMMENDATION TO INFRINGE ANY EXISTING PATENTS OR TO VIOLATE ANY FEDERAL, STATE, LOCAL, OR FOREIGN LAWS. AVANTOR PERFORMANCE MATERIALS REMINDS YOU THAT IT IS YOUR LEGAL DUTY TO MAKE ALL INFORMATION IN THIS MSDS/SDS AVAILABLE TO YOUR EMPLOYEES.
SAFETY DATA SHEET

1. IDENTIFICATION OF MATERIAL AND SUPPLIER

Product Identifier: Wilclear Plus® Lactate with Accelerite®
Recommended Use: In-situ Bioremediation
Recommended Restrictions: none known

Supplier Name: JRW Bioremediation, LLC
Address: 14321 W. 96th Terrace
Lenexa, KS 66215
Telephone: 913-438-5544
EMERGENCY Telephone: 800-779-5545 x 116 (Mon-Fri 9am-5pm CST)
913-961-6644 (afterhours)

2. HAZARD IDENTIFICATION

Health & Physical Hazards:
This product contains no substances in their current physical state that are considered to be hazardous to health and has a low order of toxicity. While the chemical, physical, and toxicological properties have not been thoroughly examined, no acute or delayed symptoms or effects have been observed to date.

Flammability Hazards:
This is a Non-Flammable liquid but it is recommended to avoid temperatures above 150°C.

Reactivity Hazards:
This product is considered stable. Thermal decomposition may lead to release of irritating gases and vapors. Hazardous polymerization is not expected to occur. Fermentation can occur when diluted with water.

OSHA Hazards:
This material is not considered hazardous by OSHA. No labels or signage are known to be required.
3. COMPOSITION / INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Components</th>
<th>CAS #</th>
<th>% by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium lactate</td>
<td>72-17-3</td>
<td>33-40%</td>
</tr>
<tr>
<td>Sodium propionate</td>
<td>137-40-6</td>
<td>0-8%</td>
</tr>
<tr>
<td>Sodium acetate</td>
<td>127-09-3</td>
<td>0-8%</td>
</tr>
<tr>
<td>Sodium butyrate</td>
<td>156-54-7</td>
<td>0-8%</td>
</tr>
<tr>
<td><strong>Total sodium carboxylates</strong></td>
<td></td>
<td><strong>45-50%</strong></td>
</tr>
<tr>
<td>Carbohydrates &amp; fermentation</td>
<td>68476-78-8</td>
<td>15-20%</td>
</tr>
<tr>
<td>metabolites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>7732-18-5</td>
<td>40%</td>
</tr>
</tbody>
</table>

4. FIRST-AID MEASURES

**Inhalation:**
Inhalation of mist may cause mild irritation of respiratory system. Move to fresh air.

**Skin Contact:**
In case of contact with skin, immediately wash with plenty of soap and water while removing contaminated clothing. Seek medical attention if skin irritation develops or persists.

**Eye Contact:**
In case of contact with eyes, immediately flush eyes with water for at least 15 minutes, lifting eyelids to facilitate irrigation. Get medical attention if necessary.

**Ingestion:**
If swallowed, get medical attention.

**Signs and symptoms of exposure:** Mild irritation to skin and eyes upon contact; mild irritation to respiratory system upon inhalation.

**Medical Conditions aggravated by exposure:** None determined. Treat symptomatically.
5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media: Water, carbon dioxide, or dry chemical.
Unsuitable Extinguishing Media: Do not use heavy water stream as it may spread or scatter.
Specific hazards from substance/mixture: Thermal decomposition may lead to release of irritating or toxic gases and vapors.
General fire hazards: No unusual fire or explosion hazards noted

Special protective equipment / precautions for fire-fighters:
Wear full protective clothing and positive pressure breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES

Methods and Materials for containment and clean up:
Contain spill with absorbent materials such as vermiculite or soil; shovel and place material in drum for disposal. Flush area with water. Surfaces may become slippery after spillage. Dispose of according to all local, state, and federal regulations at an approved waste treatment facility.

Personal precautions / Protective equipment:
Use personal protective equipment. Prevent spills, contamination, and leakage.

Environmental precautions:
No special environmental precautions required.

7. HANDLING AND STORAGE

Precautions for safe handling:
Observe good work and industrial hygiene practices. Use personal protective equipment. Avoid contact with skin, eyes, and clothing. Avoid breathing mists and vapors. Wash hands after use of this product. Do not eat, drink, or smoke while using product. Prevent spills, contamination, and leakage.

Conditions for safe storage, including any incompatibilities:
Keep container tightly closed. Keep in properly labeled containers. Store in a well ventilated, cool, dry area.
8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Control parameters: No exposure or biological limits noted for ingredients(s).

Appropriate engineering controls: Use adequate mechanical ventilation, especially in confined spaces. Temperatures best kept below 150°C.

Individual protection measures, such as Personal Protective Equipment (PPE):
- Eye/Face protection: Chemical goggles recommended.
- Skin / hand / body protection: Chemical resistant gloves recommended.
- Respiratory protection: None required under normal use in well ventilated area.
- General considerations: Use good industrial hygiene and best safety practices. When using material, do not eat, drink, or smoke. Remove and wash any contaminated clothing before storage or re-use.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance: light to medium brown
Physical state: liquid
Odor: slight sweet yeast-like aroma
Odor threshold: not applicable
pH: not determined
Melting point/freezing point: not determined
Initial boiling point: >100°C
Closed cup Flash point: not applicable
Evaporation rate: not determined
Flammability (solid, gas): not determined
Upper/lower flammability or explosive limits: not determined
Vapor pressure (Mg Hg): not determined
Vapor density (air = 1): not determined
Density: not determined
Viscosity: not determined
Solubility in water: completely soluble
Auto-ignition temperature: not determined
Specific Gravity (H₂O = 1): >1
10. STABILITY AND REACTIVITY

<table>
<thead>
<tr>
<th>Reactivity:</th>
<th>Non-reactive under conditions of normal use, storage &amp; transport.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical stability:</td>
<td>Stable under conditions of normal use, storage and transport.</td>
</tr>
<tr>
<td>Possibility of hazardous reactions:</td>
<td>Hazardous polymerization will not occur.</td>
</tr>
<tr>
<td>Conditions to avoid:</td>
<td>Temperatures above &gt;150°C.</td>
</tr>
<tr>
<td>Incompatible materials:</td>
<td>Fermentation can occur when diluted with water.</td>
</tr>
<tr>
<td>Hazardous decomposition products:</td>
<td>Thermal decomposition may lead to release of irritating gases and vapors.</td>
</tr>
</tbody>
</table>

11. TOXICOLOGICAL INFORMATION

No adverse health effects are expected if the product is used as intended and in accordance with this Safety Data Sheet.

Inhalation: Inhalation of mist may cause mild irritation of respiratory system. Move to fresh air.

Ingestion: If swallowed, get medical attention.

Skin: In case of contact with skin, immediately wash with plenty of soap and water while removing contaminated clothing. May cause mild irritation. Seek medical attention if skin irritation develops or persists.

Eye contact: In case of contact with eyes, immediately flush eyes with water for at least 15 minutes, lifting eyelids to facilitate irrigation. Get medical attention if necessary.

Signs & symptoms of exposure: Mild irritation to skin and eyes upon contact; mild irritation to respiratory system upon inhalation.

Carcinogenicity: Contains no known ingredient listed as carcinogen.

Mutagenicity: No known effect.

Reproductive Toxicity: No known effect.
12. ECOLOGICAL INFORMATION

Ecotoxicity: Product is not considered environmentally hazardous and is not expected to cause significant harm to aquatic, animal, or plant life.

Persistence/degradability: Readily biodegradable.

Bioaccumulative potential: Not expected to bioconcentrate or bioaccumulate.

Mobility in soil: No specific information available.

13. DISPOSAL CONSIDERATIONS

Disposal Methods:
Contain spill with absorbent materials such as clay or soil and shovel and place material in drum for disposal. Surfaces may become slippery after spillage. Dispose of according to all local, state, and federal regulations at an approved waste treatment facility.

14. TRANSPORTATION INFORMATION

DOT hazard class: Not Applicable, non-regulated
Labeling: Not Applicable
Proper Shipping Name: Wilclear® Sodium Lactate 60% Solution
NMFC#: 46400.02
Class 70

15. REGULATORY INFORMATION

Restrictions on use: None.

Other regulations: No information available or not applicable.

16. OTHER INFORMATION

The information in this SDS summarizes to the best of our knowledge at the date of issue, the chemical health and safety hazards of this material and general guidance for safe handling, use, processing, storage, transportation, disposal, and release. This information is not intended to be considered a warranty or quality specifications. The information contained relates only to the specific material designated and may not be valid if used in conjunction with other materials or in any other processes other than intended use. If further clarification or information is required, please contact JRW Bioremediation.
Safety Data Sheet

SECTION 1 – CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: DHC microbial consortium (SDC-9)

Manufacturer: CB&I 17 Princess Road, Lawrenceville, NJ 08648. Phone (609) 895-5340

CAS #: N/A (Not Applicable)

Product Use: For remediation of contaminated groundwater (environmental applications).

Material Description: Non-toxic, naturally occurring, non-pathogenic, non-genetically altered anaerobic microbes in a water-based medium.

IN CASE OF EMERGENCY CALL CHEMTREC 24 HOUR EMERGENCY RESPONSE PHONE NUMBER (800) 424-9300

SECTION 2 – COMPOSITIONS AND INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Components</th>
<th>%</th>
<th>OSHA PEL</th>
<th>ACGIH TLV</th>
<th>OTHER LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Hazardous Ingredients</td>
<td>100</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

DHC microbial consortium (SDC-9) comprised of microorganism of the genus *Dehalococoides*, *Dehalogenimonas*, *Desulfovibrio*, *Desulfitobacterium*, and methanogenic archaeabacteria.

SECTION 3 – 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.

Ingestion: Ingestion of large quantities may result in abdominal discomfort including nausea, vomiting, cramps, diarrhea, and fever.

Inhalation: Hypersensitive individuals may experience breathing difficulties after inhalation of aerosols.

Skin Absorption: May cause irritation upon prolonged contact. Hypersensitive individuals may experience allergic reactions.

Eye contact: May cause irritation unless immediately rinsed.

SECTION 4 – FIRST-AID MEASURES
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.

Inhalation: Get medical attention if allergic symptoms develop.

Skin Absorption: N/A

Skin Contact: Wash affected area with soap and water. Get medical attention if allergic symptoms develop.

Eye Contact: Flush eyes with plenty of water for at least 15 minutes using an eyewash fountain, if available. Get medical attention if irritation occurs.

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.

SECTION 5 – FIRE-FIGHTING MEASURES

Flammability of the Product: Non-flammable

Flash Point: N/A

Flammable Limits: N/A

Fire Hazard in Presence of Various Substances: N/A

Explosion Hazard in Presence of Various Substances: N/A

Extinguishing Media: Foam, carbon dioxide, water

Special Fire Fighting Procedures: None

Unusual Fire and Explosion Hazards: None

SECTION 6 – ACCIDENTAL RELEASE MEASURES

Reportable quantities (in lbs of EPA Hazardous Substances): N/A

No emergency results from spillage. However, spills should be cleaned up promptly. Absorb with an inert material and put the spilled material in an appropriate waste disposal container. All personnel involved in the cleanup must wear protective clothing and avoid skin contact. After clean-up, disinfect all cleaning materials and storage containers that come in contact with the spilled liquid.

SECTION 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 (SDC-9) 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 up to the pressure of 15 psi. Do not exceed pressure of 15 psi during transfer of DHC microbial consortium (SDC-9) from kegs. Don’t open keg if content of the keg is under pressure.

DHC microbial consortium (SDC-9) may be stored for up to 3 weeks at temperature 2-4°C without aeration. Avoid freezing.

SECTION 8 – EXPOSURE CONTROLS/PERSONAL PROTECTION

Hand Protection: Rubber, nitrile, or vinyl gloves.

Eye Protection: Safety goggles or glasses with side splash shields.

Protective Clothing: Use adequate clothing to prevent skin contact.

Respiratory Protection: N95 respirator if aerosols might be generated.

Ventilation: Provide adequate ventilation to remove odors.

Other Precautions: An eyewash station in the work area is recommended.

SECTION 9 – PHYSICAL AND CHEMICAL PROPERTIES


Boiling Point: 100°C (water) Specific Gravity (H₂O = 1): 0.9 - 1.1
Vapor Pressure @ 25°C: 24 mm Hg (water) Melting Point: 0°C (water)
Vapor Density: N/A Evaporation Rate (H₂O = 1): 0.9 - 1.1
Solubility in Water: Soluble Water Reactive: No
pH: 6.0 - 8.0

SECTION 10 – STABILITY AND REACTIVITY

Stability: Stable

Conditions to Avoid: None

Incompatibility (Materials to Avoid): Water-reactive materials

Hazardous Decomposition Byproducts: None
SECTION 11 – TOXICOLOGICAL INFORMATION

This product contains no toxic ingredients. SDC-9 consortium has tested negative for pathogenic microorganisms such as Bacillus cereus, Listeria monocytogenes, Salmonella sp., Fecal Coliform, Total Coliform, Yeast and Mold and Pseudomonas sp.

SECTION 12 – ECOLOGICAL INFORMATION

Ecotoxicity: this material will degrade in the environment.

SECTION 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 SDC-9 consortium with 1 part (by volume) of bleach. Dispose of in accordance with local, state and federal regulations.

SECTION 14 – TRANSPORT INFORMATION

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

SECTION 15 – REGULATORY INFORMATION

Federal and State Regulations: N/A

SECTION 16 – OTHER INFORMATION

MSDS Code: ENV 1033
MSDS Creation Date: 10/06/2003
Last Revised: August 17, 2016.

While the information and recommendations set forth herein are believed to be accurate as of the date hereof, CB&I MAKES NO WARRANTY WITH RESPECT HERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.
APPENDIX C

Draft Field Forms
# Chain of Custody

## CB&I Federal Services
- **Company Name:** CB&I Federal Services
- **Address:** 2449 Louisiana Blvd NE, Ste 300
- **City / State / Zip:** Albuquerque, NM 87110
- **Manager:**
- **Phone/Fax Number:**
- **Send Report To:** Susan Hughe
- **Phone/Fax Number:** 925-268-2099 (work)/925-827-5927 (fax)
- **Address:** 4005 Port Chicago Highway
- **City:** Concord, CA 94520

## Requesting Testing Program

<table>
<thead>
<tr>
<th>Lab Sample Number</th>
<th>Sample Identification</th>
<th>Date</th>
<th>Time</th>
<th>G/C</th>
<th>PRESERVATION</th>
<th>Container</th>
</tr>
</thead>
</table>

## Collection Information
- **Lab to filter dissolved metals:**
- **Sampler(s) Name(s):**
- **Retrieved By:**
- **Date:**
- **Time:**
- **Matrix:**
- **Method Codes:**
  - C = Composite
  - Q = Grab

## Matrix Codes
- **DW = Drinking Water**
- **GW = Ground Water**
- **WW = Waste Water**
- **SW = Surface Water**
- **LIQ = Other Liquid**
- **SOL = Other Solid**
- **SO = Soil**
- **SL = Sludge**
- **CP = Chip Samples**
- **WP = Wipe Samples**
- **GS = Air Sample**

## Project Specific:
- **I**
- **II**
- **III**
- **Date Due / QC Required:**
LOW FLOW GROUNDWATER PURGE LOG

Project Name: ___________________________ Well ID No.: ___________________________
Site / SWMU No.: ________________________ Date: _________________________________
Weather: _______________________________ Time: _________________________________
Field Crew: ______________________________ Crew Signature: _______________________
Review Signature: ______________________ Date Review: ___________________________

WELL OBSERVATIONS

Protective Casing / Vault:  Intact - Damaged -  Locked: Yes - No  Well ID Mark: Yes - No
Notes: __________________________________________________________

WELL DETAILS AND EQUIPMENT USED

<table>
<thead>
<tr>
<th>WELL DETAILS</th>
<th>MEASUREMENT</th>
<th>EQUIPMENT / MODEL</th>
<th>ID NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth to Well Bottom</td>
<td>ft</td>
<td>Parameter Meter</td>
<td></td>
</tr>
<tr>
<td>Pre-Purge Depth to Water</td>
<td>ft</td>
<td>Turbidity Meter</td>
<td></td>
</tr>
<tr>
<td>Depth to Top of Screen</td>
<td>ft</td>
<td>Pump</td>
<td></td>
</tr>
<tr>
<td>Depth to Bottom of Screen</td>
<td>ft</td>
<td>Field Alkalinity</td>
<td></td>
</tr>
</tbody>
</table>

PURGING INFORMATION

Description first water purged:

<table>
<thead>
<tr>
<th>Date and / or Time</th>
<th>Gallons Removed</th>
<th>Depth to Groundwater</th>
<th>Temp (°C)</th>
<th>pH</th>
<th>Spec Cond (mS/cm²)</th>
<th>DO (mg/L)</th>
<th>ORP (mV)</th>
<th>Turbidity (NTU)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values Prior to Sampling

Field Alkalinity Result __________________________________________
Sample Collection Log
Project Name Here

Location Code ___________          RFA/COC Number__________________
Sample Number _______________      Collection Date _________________
Sampling Method ________________  Collection Time _________________
Sample Type ________________      Start Depth _________________
QC Code________________________  End Depth _________________
Sampling Equipment_______________ Sample Matrix _________________
QC Partners____________________  Sample Team________________

Containers:

<table>
<thead>
<tr>
<th>Analytical Suite</th>
<th>Frtn</th>
<th>Filtered</th>
<th>Qty</th>
<th>Size</th>
<th>Container Type</th>
<th>Preservative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments/Descriptions:
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

Logged By/Date: ___________________          Reviewed By/Date: ________________
## Visual Classification Of Soils

**CB&I Federal Services, LLC**

<table>
<thead>
<tr>
<th>Project Number:</th>
<th>Project Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring Number:</td>
<td>Coordinates:</td>
</tr>
<tr>
<td>Elevation:</td>
<td>Date:</td>
</tr>
<tr>
<td>GWL: Depth</td>
<td>Date/Time:</td>
</tr>
<tr>
<td>Depth</td>
<td>Date Completed:</td>
</tr>
<tr>
<td>Drilling Methods:</td>
<td>Page:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type &amp; No.</th>
<th>Blows On Sampler (in.)</th>
<th>Recovery (in.)</th>
<th>Description</th>
<th>USGS Symbol</th>
<th>Measured Consistency (SG)</th>
<th>Wall Consistency</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

- Drilling Contractor: ____________________________
- Drilling Equipment: ____________________________
- Driller: ____________________________

Form Number 252.3
Well Development Record

Project Name: __________________________
Location: ______________________________
Personnel: ____________________________
Date: _________________________________
Casing Diameter (ID): __________________
Total Depth (ft, BGL): __________________

Drilling Method: 

[ ] Drilled 
[ ] Boring 
[ ] Other ____________________________

Development Date: ____________________
Depth to Water Before Developing Well (ft, BGL): __________________

Vol. (V) Purge Factor Volume to Purge

Height of Water Column feet = gal * 1 = __________________

\[ V = (B \cdot r_1^2 \cdot L_1 \cdot 7.48) + (B \cdot r_2^2 \cdot L_2 \cdot 7.48) + (H_2O \text{ added during drilling/installation}) \]

Purge Factor = __________________________
Volume to Purge = ______________________

Depth Purging From: ____________________
Time Purging Begins: ____________________
Weather: ______________________________
Screened Interval (ft BGL): __________________
Equipment Nos.: ________________________
pH Meter: ____________________________
EC Meter: ____________________________
Turbidity Meter: ________________________

Equipment Decontaminated Prior to Development: [ ] Y [ ] X [ ] N
Describe: Steam Cashed

Collected Sample of Water Added to Well: [ ] Y [ ] N [ ] X
Describe: ______________________________

Comment: ______________________________

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Water Level (ft. Below TOC)</th>
<th>Volume Removed (gal)</th>
<th>Temp °C</th>
<th>pH</th>
<th>EC (microsiemens)</th>
<th>Turbidity N.T.U.</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
* Water Levels - Reported to the nearest 0.1 ft
* pH - Reading rounded to 0.1 pH units
* Water Temperature - Reported to nearest 1.0 °C
* Turbidity reported in NTU rounded to whole #
* GPAH = Gallons Per Hour

Where:
\[ B \] = Outside diameter of the pipe or borehole
\[ r_1 \] = radius of the casing
\[ r_2 \] = radius of the borehole
\[ L_1 \] = length of water column inside the casing and screen in ft
\[ L_2 \] = length of saturated portion of the sand pack in ft

7.48 gallons/cubic foot conversion from cubic feet to gallons
### Field Activity Daily Log

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Project No.</th>
</tr>
</thead>
</table>

#### Field Activity Subject:

**Description of Daily Activities and Events:**

<table>
<thead>
<tr>
<th>VISITORS ON SITE:</th>
<th>CHANGES FROM PLANS AND SPECIFICATIONS AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>WEATHER CONDITIONS:</th>
<th>IMPORTANT TELEPHONE CALLS:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CB&amp;I PERSONNEL ON SITE:</th>
<th>SIGNATURE:</th>
<th>DATE:</th>
</tr>
</thead>
</table>

0.25 in x 0.25 in
# Groundwater Extraction Well Development

**Project Name:**

**Location:**

**Personnel:**

**Start Date:**

**End Date:**

**Well No.:**

**Date Installed:**

**Casing Diameter (I.D.):**

**Total Depth (ft. BGS):**

---

**Method of Development:**
- [ ] Surging
- [ ] Bailing
- [ ] Pumping
- [ ] Jetting
- [ ] Original Development
- [ ] Redevelopment
- [ ] Other

**Depth to Water Before Developing Well (ft. BGS):**

**Screened Interval (ft. BGS):**

**Weather:**

**Equipment Numbers:**

**pH:**

**Conductivity:**

**Turbidity:**

**Equipment Decontaminated Prior to Development?**
- [ ] Yes
- [ ] No

**Describe:**

**Collected Sample of Water Added to Well?**
- [ ] Yes
- [ ] No

**Describe:**

**Comments:**

---

**Summary of development procedure, including key decision-points, calculations, and observations (described in detail in the following pages):**

---
## Bailing

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Total Volume Bailed (gallons)</th>
<th>Imhoff Cone Measurement (mL sediment per L water)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Surging

<table>
<thead>
<tr>
<th>Interval (ft lbs)</th>
<th>Date</th>
<th>Start Time</th>
<th>End Time</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Groundwater Extraction Well Development

<table>
<thead>
<tr>
<th>Pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
</tbody>
</table>
# Groundwater Extraction Well Development

## Jetting

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Depth (ft lbs)</th>
<th>Jetting Rate (gpm)</th>
<th>Pumping Rate (gpm)</th>
<th>Imhoff Cone Measurement (mL sediment per L water)</th>
<th>Comments</th>
</tr>
</thead>
</table>