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Revitalizing Auto Communities Environmental Response (RACER) Trust

INTERIM MEASURES WORK PLAN: LOWER 1,4-DIOXANE BIOSPARGE

Lansing Industrial Land
Lansing, Michigan

October 19, 2018

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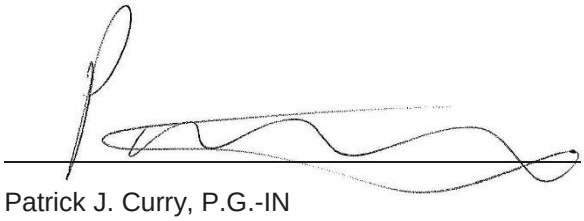

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ACRONYMS AND ABBREVIATIONS

APC	Adams Plating Company
bgs	Below Ground Surface
CFR	Code of Federal Regulations
cm	Centimeter
CSM	Conceptual Site Model
DAP	Diammonium Phosphate
DO	Dissolved Oxygen
DRC	Declaration of Restrictive Covenant
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
IGMP	Interim Groundwater Monitoring Program
IM	Interim Measure
LEL	Lower Explosive Limit
LNAPL	Light Non-Aqueous Phase Liquid
MDEQ	Michigan Department of Environmental Quality
NFPA	National Fire Protection Association
O&M	Operations and Maintenance
ORP	Oxidation-reduction Potential
%	Percent
PFAS	Per- and Polyfluoroalkyl Substances
PFM	Passive Flux Meter
PIP	Public Involvement Plan
PLC	Process Logic Controller
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
RACER	Revitalizing Auto Communities Environmental Response
RCRA	Resource Conservation and Recovery Act
ROI	Radius of Influence
SCFM	Standard Cubic Feet per Minute

SDS	Safety Data Sheet
TKN	Total Kjeldahl Nitrogen
TOC	Total organic carbon
UCL	Upper Confidence Limit
µg/L	Micrograms per liter

1 INTRODUCTION

Revitalizing Auto Communities Environmental Response (RACER) Trust retained Arcadis U.S., Inc. (Arcadis) to provide consulting services for the Lansing Plants 2, 3, and 6 (Site) located in Lansing, Michigan (see Figure 1). The purpose of this Interim Measures Work Plan (Work Plan) is to provide information to support Michigan Department of Environmental Quality's (MDEQ) approval of the biosparging interim measure (IM) proposed for implementation at the Site. It is noted that even though this Work Plan is being submitted as an interim measure while other matters related to the Site are being addressed, it is intended that this interim measure will be the final corrective measure to address the lower 1,4-dioxane plume.

The application of enhanced in situ co-metabolic biodegradation is a technology used for decades to mitigate chlorinated volatile organic compounds. More recently, research and field demonstrations have shown enhanced co-metabolic biodegradation of 1,4-dioxane is a viable mechanism for treating 1,4-dioxane in groundwater. Enhanced in situ co-metabolic biodegradation using biosparging is the recommended IM remedy for the lower 1,4-dioxane plume at the Site. Biosparging is a remedy in which propane, oxygen, and nutrients, are delivered to the subsurface through sparge points to stimulate existing microorganisms, also known as propanotrophs, and/or injected propanotrophs, to enhance in situ co-metabolic biodegradation of 1,4-dioxane. Co-metabolic biodegradation relies on biosparging to stimulate propane oxidizing bacteria to produce an enzyme that degrades 1,4-dioxane while using propane as its primary carbon source for metabolism (Vainberg et al. 2006).

The biosparge system will consist of installation of sparge points to deliver propane and oxygen, to stimulate microbes that have the ability to biodegrade 1,4-dioxane and nutrients, into the targeted treatment zones within the weathered bedrock. The sparge points will be installed in transects, perpendicular to the direction of groundwater flow, allowing the natural groundwater gradients to transport impacted groundwater through the treatment zone. As groundwater flows through the transects, microbes will biodegrade the 1,4-dioxane within the in-situ biodegradation zones that are created by the biosparge system and treated groundwater will move downgradient with the natural flow of groundwater reducing groundwater concentrations throughout the plume. Treatment effectiveness will be assessed through a performance monitoring program; plume stability will continue to be evaluated through an MDEQ approved groundwater monitoring program.

Arcadis has prepared the following work plan to detail the biosparge system to facilitate biodegradation in the lower 1,4-dioxane plume. The details provided in the work plan represent a 30% design and are subject to updates as the design is progressed to through 90% design.

1.1 Lower 1,4-Dioxane Plume Overview

The lower 1,4-dioxane plume is present in the deep overburden and weathered bedrock at depths generally ranging from 70 to 90 feet below ground surface (bgs). The lower 1,4-dioxane plume, extending from the Plant 3 "coliseum" area to the south-central portion of Plant 2, has been delineated with numerous vertical aquifer profiling borings and monitoring wells. A cross section of the lower 1,4-dioxane plume and the general Site layout are presented on Figure 2. At the 1,4-dioxane source area near the coliseum, the plume is present in the saturated, deep overburden and weathered bedrock zones. South of

the Plant 3 source area, the lower 1,4-dioxane plume coalesces and migrates primarily within the weathered bedrock zone on the northern portion of Plant 2.

The thickness of the weathered bedrock zone is variable and the transition from weathered bedrock to consolidated rock is gradational. The weathered bedrock zone is estimated to be approximately 10 to 15 feet thick. The bedrock consists of the Grand River Formation to the north and Saginaw Formation to the south. The contact between these units is in the occurs along a northeast trending line across the northeastern portion of Plant 2 (Figure 3). The Grand River Formation consists of a fine- to medium-grained sandstone that occupies erosional valleys within the Saginaw Formation (United States Geological Survey 2000). The horizontal hydraulic conductivity of the weathered Grand River Formation is typically two to three times greater than the Saginaw Formation. The Saginaw Formation consists of finer-grained sandstone with intermittent layers of shale that vary from sub-centimeter to several feet thick. The anisotropy inherent to the Saginaw Formation, both vertically and horizontally, reduces the overall permeability and limits vertical connectivity. The weathered bedrock zone in each formation is relatively more permeable than the underlying less weathered bedrock.

Groundwater elevation measurements collected from the monitoring wells installed along the lower 1,4-dioxane plume reflect complex weathered bedrock structure. Large vertical gradients are observed within the Saginaw Formation at Plant 2 (typically 0.3 to 0.5 feet/feet). As a result, the observed groundwater elevation within the Saginaw Formation varies greatly depending on the depth of a weathered bedrock well. Based on the evaluation presented in the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Phase 2 Supplemental Report (Arcadis 2014), Passive Flux Meter (PFM, Enviroflux, LLC) evaluation (Arcadis 2015; as revised), and a tracer study completed in December of 2015 (Arcadis 2016), the groundwater flow within the weathered bedrock is southerly, consistent with the plume morphology.

1.2 Corrective Action Objectives

RCRA regulations and guidance describe the overall goal of remediation as 1) protection of human health and the environment, 2) attaining media cleanup objectives, 3) controlling source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste or substances, and 4) complying with applicable standards for waste management. The overall corrective action objective for the Site is to protect human health and the environment by achieving RCRA Corrective Action Complete with Controls (i.e., non-residential closure per MDEQ standards). Portions of the Site are located in the City of Lansing and Lansing Township Wellhead Protection Areas.

Site related 1,4-dioxane has been delineated onsite horizontally and vertically to below the MDEQ 1,4-dioxane drinking water criteria of 7.2 μg/L. There will be a Declaration of Restrictive Covenant (DRC) recorded on the deeds for the Site that includes a restriction on installing wells or other devices to extract groundwater for any use so the drinking water pathway for on-Site groundwater will not be complete. The Conceptual Site Model (CSM) shows that at the current on-Site concentrations there is minimal risk that 1,4-dioxane from the Site will migrate off-Site to the municipal wells at detectable concentrations (greater than 0.2 μg/L). At current on-Site concentrations there is significantly less risk that 1,4-dioxane from the Site would reach the municipal wells above the drinking water standard of 7.2 μg/L.

With the recognition that residential drinking water criteria for 1,4-dioxane is 7.2 μg/L continued protection of the municipal drinking water supply wells by preventing Site-related 1,4-dioxane impacted groundwater from migrating off-Site laterally in the weathered bedrock zone at concentrations greater than 7.2 ug/L and reducing the potential for migration of 1,4-dioxane downward substantially into less weathered bedrock are the long-term goals of lower 1,4-dioxane remediation. The proposed biosparge remedy is being implemented with the short-term goal to reduce concentrations of Site-related 1,4-dioxane concentrations along the core of the lower 1,4-dioxane weathered bedrock plume. The biosparge system will be installed and operated to meet the short and long-term objectives.

Performance monitoring along the western property boundary may be complicated by the potential comingling of 1,4-dioxane associated with the Adam's Plating Company (APC) to the west of the Site (Figure 3). Further, APC is located between the Site and the municipal well to the west. As stated, the objective of the biosparge system is to address Site related 1,4-dioxane (i.e. RACER's contribution), not impacts contributed by APC.

With the complex hydrogeological setting of the lower 1,4-dioxane plume, utilizing a flux-based monitoring program that aligns with the current understanding of transport is critical to evaluate remediation performance. Only wells that monitor mass flux zones will be used to monitor performance of the biosparge system (i.e. wells screened within the weathered bedrock and bedrock); monitoring wells that monitor lower permeability zones will not be included (i.e. wells screened in the saturated overburden and till). Implementing flux-based performance monitoring aligns with the short and long-term objectives of the biosparge system.

Monitoring data will be utilized to assess the performance of the system and optimize the operation as needed, but annually at a minimum. Optimization may include adjustment of the operational parameters, shutting down portions of the system if the long-term objective has been achieved, focusing treatment on recalcitrant areas, and/or updating the system to be in-line with the progress of the state-of-the science relative to 1,4-dioxane biodegradation.

The biosparge system will be operated until:

- Further reduction in groundwater concentrations require extra ordinary efforts, (i.e. the system reaches a point of diminishing returns). The currently proposed process for the evaluation of the point of diminishing returns is detailed in the performance monitoring section of this work plan but it is recognized that it will likely be appropriate to update the evaluation process, in collaboration with MDEQ, over the course of the operation of the biosparge system because information that will allow for better operation and evaluation is expected to become available as the system is operated and monitoring results are received and evaluated;
- 1,4-dioxane concentration trends for Site related 1,4-dioxane in weathered bedrock and bedrock monitoring wells along the core of the plume and in monitoring wells along the western Plant 2 property boundary show stable to decreasing trends utilizing statistical evaluation (e.g. Mann-Kendall or other method acceptable to MDEQ); or,
- The short and long-term objectives have been met.

In summary, even though current information does not indicate that Site related 1,4-dioxane has or will reach the municipal wells at concentrations greater than 7.2 ug/L, on-Site reduction of Site related 1,4-

dioxane mass is proposed to increase protection of the municipal drinking water supply wells, which is the long-term goal of remediation at the Site. The biosparge system will be operated to remediate the lower 1,4-dioxane plume to reach the point of diminishing returns, stable or decreasing trends of Site related 1,4-dioxane along the core and at the western property boundary, or until the short and long-term objectives have been met.

1.3 Biosparge Pilot and Pre-Design Study Summary

A biosparge pilot test was conducted at the Site in late 2016 (Arcadis 2017a). Results of the pilot test indicated that 1,4-dioxane could successfully be co-metabolically degraded at the Site and this technology was a feasible full-scale corrective measure to remediate the lower 1,4-dioxane plume. However, the heterogenous nature of the weathered bedrock (sandstone and shale in the Saginaw Formation) resulted in non-uniform distribution of gases and limiting 1,4-dioxane biodegradation at some locations in the pilot test area during the 2016 biosparge pilot test.

To optimize the technology for full-scale implementation Arcadis conducted a pre-design study in 2017-2018 in accordance with the MDEQ-approved workplan. The objectives of the study were to determine if gas distribution can be optimized in the weathered bedrock through sand lens enhancements, to define the radius of influence (ROI) of the active treatment zone, to evaluate the potential for lateral migration of propane and pressure buildup in the weathered bedrock, and to optimize operational parameters.

Prior to the study, horizontal sand lenses were installed in the treatment zone to enhance distribution of dissolved gasses, nutrients, and microorganisms, thereby increasing the volume of the active treatment zone. The biosparge pre-design study began in late 2017 and operated through mid-April 2018. Results indicated that:

- Sand lenses can be installed in the weathered bedrock
- The enhancements improved gas distribution and 1,4-dioxane treatment
- Target radius of influence of 15 feet was consistently achieved based on multiple lines of evidence
- Residual sand lens mixture compounds dissipated quickly and did not migrate outside the pilot test area
- Less propane was required than was used in the 2016 pilot (70% less)
- Propane migration was minimal; no vapors and only a few minimal detections (maximum detection of 5.2 µg/L) were observed in perimeter monitoring wells

2 BIOSPARGE SYSTEM

Biosparging consists of the installation of sparge points to deliver propane and oxygen, to stimulate microbes that can biodegrade 1,4-dioxane, in the targeted treatment zone within the weathered bedrock. The sparge points will be installed in transects, perpendicular to the direction of groundwater flow, allowing the natural groundwater gradients to transport impacted groundwater through the treatment zone (Figure 3). As groundwater water flows through the transects, microbes will biodegrade the 1,4-dioxane within the in-situ biodegradation zones that are created by the biosparge system.

The biosparge system will include:

- Biosparge points with high-permeability sand lenses to deliver compressed gases to the treatment zone;
- Sub-grade conveyance network of piping to deliver gases to the sparge points;
- Above-grade injection equipment, including an air compressor for the delivery of oxygen, bulk propane tank to supply propane, as well as piping, valving and manifolds to control flow and pressure to sparge points; and
- A network of performance and perimeter monitoring wells (plume stability will be monitored as part of the IGMP)

The details provided in the work plan represent conceptual-level design and are subject to updates during the design process if improvements and/or efficiencies can be identified. The propane biosparge pilot test system building, already on-Site, will be upgraded and relocated from its current location at the south end of Plant 2 for use during the full-scale implementation. Additionally, biosparge points installed for the 2016 pilot study and 2017-2018 predesign study and existing monitoring wells will be incorporated into the full-scale well network as appropriate.

2.1 Biosparge Points

A total of approximately 56 vertical biosparge points will be installed in five transects throughout the lower 1,4-dioxane plume (Figure 3). Biosparge points will be screened in the weathered bedrock interval. Biosparge point construction will be similar to the design used in the 2017-2018 pre-design study, but is subject to updates during the design process if improvements and/or efficiencies can be identified.

2.1.1 Transects

Transect spacing is based on the range of hydraulic conductivities, average groundwater concentrations in the treatment area, and required pore flushes to reduce groundwater concentration to meet the performance objectives. Data collected as part of the hydraulic testing pilot test and tracer test were utilized to evaluate transect spacing. For the purposes of hydraulic calculations, the lower 1,4-dioxane plume was divided into three sections to account for hydrologic conditions at the Site:

- Section 1 represents the Grand River Formation and is characterized by relatively higher hydraulic conductivity weathered sandstone. Section 1 extends from the northern tip of the plume in Plant 3 to the Grand River / Saginaw Formation divide in northern Plant 2. Groundwater velocity in Segment 1

was estimated at 275 to 518 feet per year. Ongoing trend analyses are completed on wells in the former coliseum source area and show that under current conditions 1,4-dioxane concentrations in the weathered bedrock upgradient of the northern most transect will reach the treatment goal within 6 years with no direct treatment.

- Section 2 represents the finer grained Saginaw Formation and extends from the Grand River / Saginaw Formation contact to the light non-aqueous phase liquid (LNAPL) plume in Area 5-2. Estimated groundwater velocity is 85 to 265 feet per year.
- Section 3 represents the Saginaw Formation and extends from the LNAPL plume in Area 5-2 to the toe of the 1,4-dioxane plume in Southern Plant 2. Estimated groundwater velocity is 25 to 54 feet per year.

Five biosparge transects were chosen based on this hydraulics analysis, with more transects in the Saginaw Formation (Sections 2 and 3) where slower groundwater velocity results in slower pore flushing. Within each transect, individual biosparge points will be spaced approximately 30 feet on center. This spacing assumes a ROI of 15 feet, based on the 2017-2018 pre-design study.

2.1.2 Biosparge Casing Installation

The biosparge points will be installed using the same method employed during the 2017-2018 Pre-Design Study. Borings will be advanced using roto-sonic drilling methods. The first step will consist of installing a 4-inch schedule 40 poly vinyl chloride (PVC) outer casing to a depth of approximately 78 to 80 feet bgs (Figure 4). During installation of each biosparge point the contact between weathered bedrock and bedrock will be estimated for appropriate screen placement. The bottom of the casing will be field determined to target the base of the weathered bedrock zone, above the transition to competent bedrock. Centralizers will be installed on the PVC riser at a spacing of every 10 feet, with one centralizer placed as close to the bottom of the biosparge point as possible. The solid casing will be completed with a threaded cap on the end. The annular space will be tremie grouted to grade in two lifts (a standard mix of Portland cement and 3-4 percent [%] bentonite). The annular space between the 8-inch borehole wall and 4-inch outer PVC casing will be completely sealed with grout so that injected materials (propanotrophs, if necessary, propane, nutrients, etc.) are focused in the target interval and do not migrate to overlying or underlying intervals.

Lessons learned in the Pre-Design Study related to grouting the biosparge points will be applied to the full-scale design. During the first month of system operation in the Pre-Design study in December 2017, an air leak was discovered in sparge point AS-17-05 due to a seal issue associated with the inner 2-inch PVC riser. The leak was repaired with a Fernco seal so that the well could be operated during the pilot test. To mitigate the risk of this issue recurring and more reliably seal the inner annulus, additional measures may be taken including but not limited to increasing the bentonite content of the cement mixture, increasing the diameter of the annular space, and/or using improved centralizers. Therefore, the biosparge point design may be updated if improvements are identified during the bidding or installation processes. All well construction materials will be free of PFAS compounds. Any water coming in contact with construction materials will be verified to be free of PFAS compounds, including but not limited to water used in the cement mixes.

2.1.3 Sand Lens Installation

Following installation of the outer casing, two sand lenses will be installed within each biosparge point using the same method employed during the 2017-2018 Pre-Design Study. First, a high-pressure water jet will be used to cut through the blank PVC casing and annular grout and notch the formation in preparation for the sand lens injection. The two notches will be installed approximately five feet apart vertically, with the bottom lens approximately two feet above the top of competent bedrock. The actual locations of the notches will be determined based on conditions encountered in the field.

Next, a mixture of water, sand, guar gum, borax, and LEB-H – endo-1,4-R-mannase (sand mixture) will be prepared above grade in tanks for injection into the formation as described in the pre-design study work plan (Arcadis 2017b). The sand mixture is injected through the notch and then propagates radially away from the casing, creating a 0.5 to 1 centimeter (cm) thick horizontal sand lens.

Based on the 2017-2018 pre-design study, the radius of the sand lens is expected to be approximately 15 feet. The Safety Data Sheets (SDSs) for all injected materials are included in Appendix A. Appendix B provides a description of the estimated quantities of each material per sparge point, subject to change based on conditions encountered in the field. All sand lens materials will be free of PFAS compounds. Any water coming in contact with construction materials will be verified to be free of PFAS compounds, including but not limited to water used in the sand lens mix.

2.1.4 Biosparge Point Completion

Following the creation of the sand lenses, a 2-inch diameter biosparge point will be installed within the 4-inch PVC outer casing. The sparge point will be constructed with 2-inch diameter schedule 40 PVC riser pipe with a 2-inch diameter, approximately 10-foot long (exact length to be determined in the field), 0.010-inch continuous wire wrapped stainless steel well screen (Figure 4). Although there were no operational or performance differences observed between PVC and stainless steel screens during the 2017-2018 study, stainless steel screens will provide a benefit over the long term because they can be more vigorously rehabilitated should biofouling occur, thereby prolonging biosparge point lifespan and reducing replacement costs.

Screen length and placement will be estimated prior to drilling based on target sand lens depths, but will be adjusted based on observed geology and final sand lens depths. Screens will be cut in the field such that a single screen will be centered across both sand lenses and extend approximately one foot below the lower lens and one foot above the upper lens in each biosparge point. A silica sand pack will be installed between the 2-inch diameter air sparge screen and the 4-inch blank casing to above the top of the screen. To provide an adequate seal of the borehole, one foot of very fine choker sand will be placed above the filter pack. Portland neat cement mixture will be tremied from the bottom up to ground surface.

The completed biosparge point will be set in a flush mount protective cover, vented as necessary to prevent propane vapor accumulation, and labeled. Typical biosparge point construction details are provided on Figure 4.

2.2 Sub-Grade Conveyance Network

Compressed air and propane will be delivered to the sparge points through a sub-grade conveyance piping network. The conveyance piping will be designed to allow for maximum operational flexibility while minimizing the subgrade infrastructure and power requirements. Generally, compressed air and propane will be distributed to sparge well transects via four-inch high-density polyethylene (HDPE) header lines that run from the compressor to sub-grade vaults. In the vaults the header lines will be connected to a manifold that will distribute compressed gases to individual sparge wells via one-inch HDPE laterals (Figures 3, 5, and 6). Two four-inch header lines will run from the compressor building to each of the four sub-grade valve vaults (Figure 3), the central transect will not have a vault as the manifolds will be housed within the main treatment building. There will be a total of ten 4-inch headers, each equipped with a solenoid valve. Within the sub-grade vaults (and within the treatment building for the central transect), the four-inch headers will manifold to individual 1-inch lines running to each sparge point. The headers will be sized such that they can carry compressed gases for up to half the sparge points. The sparge points can be cycled by controlling air flow to the headers (Figure 5). In addition, at the sub-grade vaults each 1-inch sparge lateral will be equipped with a flow meter and flow control valve on the manifold to allow flow to be manually adjusted to individual sparge points (Figure 5). The sub-grade piping design may be updated if improvements are identified through the contractor procurement and installation processes.

All sparge piping will be installed below ground to accommodate potential future Site redevelopment and for safety. Piping will be installed in common trenches (Figure 6). Trenches will be finished consistent with current cover, but final cover of the trenches may change based on future site use. The approximately 550-foot section of header piping between Plants 2 and 3 will be directionally bored beneath W. Saginaw Street (Figure 3).

2.3 Above-grade Injection Equipment

Compressed gas injection equipment will include an industrial grade air compressor, propane tank, controls, valves, and instrumentation. The equipment will be housed in an enclosure in central Plant 2, except the propane tank and a short run of piping will be located outside of the enclosures (Figure 3). A second enclosure may be included to house the air compressor if it proves economical and useful in minimizing personnel exposure to high noise levels during routine O&M activities. A security fence will surround the enclosure(s) and propane tank.

Components of the system will be appropriately classified based on the potential for explosive gases by adhering to National Fire Protection Association (NFPA) code 497. The purpose of adhering to NFPA code 497 is to separate the process and electronic equipment that has the potential to spark from propane storage and distribution to prevent an explosion. Within the equipment enclosure(s), an explosion proof barrier is used to separate process and electronic equipment from the classified area around the mixed gas line. All equipment located within the classified area that is not isolated by an explosion proof barrier is considered Class I Division II and designed in accordance with NFPA code 497. The pressure release valve on the propane tank is considered a potential source of explosive vapors, and it triggers the classification of the area around it as Class I Division II. As guidance is not provided to

classify a mixed gas line, a conservative approach will be taken, and the mixed gas line will also be considered a potential source of explosive propane vapors.

An industrial grade air compressor will provide air that will serve as the carrier gas for propane. Both the compressed air line and the propane line are equipped with pressure regulators, direct-acting solenoid valves, and check valves to isolate the propane and mixed gas stream in the event of a system upset condition. Compressed air and propane will be continually metered by mass flow controllers as shown in Figure 5. System operations are controlled by a process logic controller (PLC) housed in a control panel. Power will be provided to the system by an existing 480 volt, 3-phase power pole in central Plant 2 (Figure 3).

In addition to the pressure regulators, check valves, seal-offs, equipment specifications, and process safety features, an in-line sensor will be installed immediately downstream of the air-propane mixing point to monitor the lower explosive limit (LEL) of the mixed gas delivered to the formation. If the LEL in the mixed gas line exceeds a predetermined set point, the sensor will send an alarm signal to the PLC that will shut off flows of compressed air and propane and shut down the system. In addition to the in-line LEL meter a second LEL meter is installed in the Class I Division II area to monitor ambient breathing zone air within the enclosure near process equipment and supply lines. The set point for this sensor is 0.0% of the LEL; should any amount of propane be detected within the breathing zone the system shuts down and an alarm condition is sent to the operator.

2.4 Monitoring Equipment

The following equipment will be used throughout the well monitoring network to determine the influence of the sparging:

- Transducers and water level meters to monitor water levels prior to and during system operation
- Dissolved oxygen (DO) meters to monitor dissolved oxygen content prior to and during system operation
- LEL detectors to monitor propane concentrations in the Class I Division II partitioned area, the test area, and perimeter well heads prior to and during system operation

2.5 Performance Monitoring Wells

Performance monitoring will target wells in the mass flux zone (i.e. weathered bedrock and bedrock wells). Performance monitoring will be integrated into an overall Site groundwater monitoring program for the Site and then transition to long-term monitoring, subject to change (with MDEQ approval).

Approximately 16 new performance monitoring wells will be installed to assess 1,4-dioxane concentrations and associated parameters in the treatment zone (Figure 3). Proposed performance wells will be located so that each biosparge transect has at least one well approximately every 100 to 200 linear feet, and one well within its ROI, upgradient, and downgradient.

Monitoring wells will have 5-foot screens within the upper portion of the weathered bedrock(Figure 4). Final screen depths will be selected based on the screened interval of the biosparge points and depth to weathered bedrock.

Wells will be constructed of 2-inch diameter schedule 40 PVC riser pipe with a 2-inch diameter, 5-foot long, 0.010-inch slot stainless steel well screen. A silica sand filter pack will be placed to two feet above the screen. The remaining annular space will be filled with a bentonite grout seal. Monitoring wells will be set in a flush mount protective cover and labeled. Monitoring wells within the ROI of the transects will be fitted with a sealing cap to mitigate short circuiting of sparged gases. Typical monitoring well construction details are provided on Figure 4.

Existing monitoring wells will be incorporated into the performance monitoring network as applicable. Plume stability will be monitored through the monitored plume stability component of an overall Site groundwater monitoring program.

3 OPERATION

3.1 Start-Up

Following system installation, the system will begin operating in a start-up/shake-down phase. During operation, air and propane will be delivered to the biosparge points in cycles controlled by the PLC. The duration and frequency of these flow cycles, air and propane flow rates, and other system operating parameters will be initiated based on the pre-design testing and optimized during the start-up phase based on the ability of the formation to accept the gases into the newly installed sparge points and the observation of dissolved oxygen in the nearby monitoring well network. During this initial startup phase, flow cycles and other operational settings will be adjusted for optimal dissolved-phase propane and oxygen distribution within the formation in the treatment area. LEL will be monitored in the headspace of the biosparge points and nearby monitoring wells on a bi-weekly basis during the initial start-up period, and at a reduced frequency during normal operations.

3.2 Nutrient and Bioaugmentation Injections

Following start-up, nutrient amendment solutions will be injected into the biosparge points to stimulate growth of native propanotrophs in the formation, as needed. The nutrient amendment solution will be similar to those injected during the 2016 biosparge pilot test and 2017-2018 pre-design study (Arcadis 2017b). Approximately 20 pounds of diammonium phosphate (DAP) mixed with 175 to 200 gallons of water will be injected into each of the biosparge points. Based on research and field pilot testing at the Site, additional nutrient injections will be required during system operation to maintain biodegradation and optimize system performance. Nutrient injections will be completed as needed, based on the results of performance monitoring described in Section 4.

The 2016 biosparge pilot test and 2017-2018 pre-design study (Arcadis 2017b) showed reduction in 1,4-dioxane concentrations prior to bioaugmentation. Therefore, bioaugmentation will only be completed to optimize system performance if the degradation of 1,4-dioxane becomes stalled before reaching the remedy goal and addition of supplemental propanotrophs (i.e. ENV425) is warranted. If needed, the bioaugmentation solution will be similar to those injected during the 2016 biosparge pilot test and 2017-2018 pre-design study (Arcadis 2017b). The bioaugmentation would include injecting approximately four liters of bioaugmentation solution containing the propanotroph culture ENV425 into the formation followed by a nutrient injection as described above. Safety data sheets for propane, ENV425 microbial culture, and DAP are included in Appendix A.

3.3 Operating Strategy

Propane is expected to be delivered to the formation in the mixed gas stream at a concentration between 15% and 35% of the LEL, similar to the 2016 pilot test and 2017-2018 pre-design study. The total gas flowrate to each of the biosparge points will be determined during startup testing and may be up to 10 standard cubic feet per minute (SCFM), but is anticipated to be in the range of two to five SCFM. Ongoing research and field studies indicate the amount of propane required may be less than previously understood. In any case, aerobic conditions are necessary to support biodegradation of 1,4-dioxane;

therefore, the system will be designed with the operational flexibility to adjust the propane and air flow rates independently. The system will also be designed to allow for injection of air only, similar to the 2017-2018 pilot study.

Wells will be capped to prevent gases from short circuiting through the well casings. The system will be immediately shut down if propane is detected above 10% LEL in ambient air or gases cannot be injected at safe pressures. The system will be updated to eliminate the safety concern.

3.4 Operation and Maintenance

Operation and maintenance (O&M) activities will be conducted bi-weekly during start-up and at a reduced frequency during normal operations. Routine O&M activities will include taking system readings of pressure, temperatures, and flow. Electrical usage and compressor hours will be recorded during each O&M visit. Compressor oil levels shall be checked during each O&M visit and oil shall be replaced or topped off as required. Regular maintenance of the compressor should be conducted monthly.

Non-routine O&M visits will include as-needed system troubleshooting, equipment repairs, sparge point rehabilitation, and maintenance bioaugmentation and/or nutrient injections. An O&M plan will be prepared prior to implementation once design details have been substantially finalized. All O&M and sampling activities will comply with the Site-specific Health and Safety Plan (HASP) (Arcadis 2017c).

3.5 Shutdown Evaluation

The system will be operated adaptively in real time to most effectively and efficiently meet performance objectives. The adaptive design of the system will allow sparge points to be turned on and off as necessary to optimize performance.

As performance monitoring data is collected, it will be evaluated, and actions will be recommended to MDEQ as appropriate. At a minimum the evaluation of the system performance will be documented and submitted to MDEQ annually. In addition to the ongoing adaptive operation of the biosparge system, the IM will be reviewed every 5 years to assess system performance and alignment with the overall Site objectives at that time.

The performance objectives presented in Section 1.2 will be utilized to evaluate when it is acceptable to shut down particular sparge points, transects, or the entire biosparge system. Changes would be implemented after MDEQ approval. The design operational period to meet the performance objectives is twelve years.

4 PERFORMANCE MONITORING

Performance monitoring will be conducted throughout the lifetime of system operation to evaluate the effectiveness of the system in meeting the performance objectives described in Section 1.2. Groundwater samples and field parameters will be collected prior to and periodically during system operation as described below.

4.1 Baseline Sampling

Prior to the initiation of full-scale operation, Arcadis will collect groundwater samples and field measurements from the performance monitoring well network. Selected IGMP network monitoring wells will function as sentinel points to monitor for the lateral migration of propane and/or pressure buildup in weathered bedrock groundwater beyond the treatment area. Wells will be sampled using standard low-flow procedures including purging of three standing well volumes prior to sampling.

Groundwater samples will be analyzed for the following parameters:

- 1,4-Dioxane

Additionally, Arcadis will record the following field parameters from all sampling locations:

- Depth to water
- pH
- DO – by optical sensor
- Oxidation-reduction potential (ORP)
- Specific conductance
- Temperature
- Turbidity

During the 2017-2018 biosparge pre-design study, boron monitoring was performed based on trace levels known to be present in the sand lens mixture. Boron was not detected above criteria in the pilot test area or surrounding area following the study and as such, boron is not included in the sampling plan for this study.

During the 2017-2018 pre-design study, total organic carbon (TOC) was monitored prior to and after the sand lens installations as a line of evidence to assess radius of influence of the biosparge points installed. Elevated TOC was detected in all of the nearby monitoring wells following sand lens installation, providing evidence for a consistent minimum 15-foot ROI in the Saginaw Formation. During full-scale installation, TOC will be monitored in all Grand River Formation biosparge points and in one biosparge point per transect in the Saginaw Formation to verify the ROI is achieved.

Prior to beginning any full-scale biosparge point installations, a representative sample of the sand lens mixture, City of Lansing tap water, and equipment rinseate blanks from the sand lens injection equipment will be analyzed for PFAS to verify that no PFAS compounds are introduced to the aquifer.

A generalized sampling plan is included on Table 1 and shows the proposed frequencies and parameters. The sampling plan may be adapted based on field conditions encountered throughout operation to ensure the objectives are met.

4.2 Routine Monitoring

Performance data associated with the biosparge system will be routinely evaluated so that ongoing optimization can be implemented during operation. The biosparge system will be designed to allow for adaptive operation over time.

- Groundwater samples and field parameters will be collected approximately quarterly during the first year of system operation, semi-annually during the second and third years, and annually thereafter. Additional sampling will be performed as needed thereafter to evaluate the effectiveness of gas distribution and biological reduction of 1,4-dioxane. Performance monitoring will generally be performed in accordance with Table 1 and as described below. Dissolved oxygen will be monitored at select wells to ensure adequate distribution of dissolved gases.
- 1,4-dioxane and propane will be monitored to confirm distribution and monitor 1,4-dioxane biodegradation rates.
- Key nutrients (total kjeldahl nitrogen and phosphorous) will be monitored to confirm optimal ratios for biodegradation.
- The field parameters listed in Section 4.1.

This sampling plan is based on information known at the time of this Work Plan. Sample parameters, locations and frequency will be re-evaluated after the first year of full scale operation and will be adjusted with MDEQ approval as needed based on observations made during full-scale operation. Interim groundwater monitoring is in progress and will continue to collect data required to verify plume stability per the *Revised Interim Groundwater Monitoring Work Plan* (Arcadis 2017c).

4.3 Data Evaluation, Reporting, and System Operation Adjustments

The data collected during the biosparge performance monitoring will be evaluated to assess the following:

- Propane and oxygen distribution within the weathered bedrock
- Optimal air/propane flow rates as well as gas injection cycle frequency and duration
- Biodegradation of 1,4-dioxane
- Potential for lateral migration of propane within weathered bedrock, by monitoring perimeter wells for elevated propane concentrations in both groundwater and well space vapor
- Potential for pressure buildup within weathered bedrock, by monitoring well-head pressures at select monitoring wells

Evaluation of this data will be used to adaptively optimize operating conditions for the system. Individual sparge points within each transect may be turned on or off to optimize performance. All sampling data will

be collected in accordance with the Site-specific Quality Assurance Project Plan (QAPP) (Arcadis 2011a), which covers field and laboratory data quality control.

Performance monitoring results will be included in the semi-annual IGMP reports.

4.3.1 Point of Diminishing Returns

The biosparge system will be operated until further reduction in groundwater concentrations require extra ordinary efforts, (i.e. the point of diminishing returns). In order to define the point of diminishing returns, performance monitoring wells will be grouped into 3 sections (Grand River, transitional, and Saginaw) and will include monitoring wells within the sparge ROI and downgradient wells. An average concentration reduction for each group of wells will be calculated after each sampling event, which will be quarterly during the first year of system operation, semi-annually during the second and third years, annually thereafter, with additional sampling performed as needed (see Section 4.2 and Table). The maximum 12-month rolling average reduction in 1,4-dioxane observed during the first three years of operation will serve as the reference reduction value. Using the first three years to determine the reference reduction value allows for completion of the start-up period and system optimization before assessing maximum reduction. All future 12-month rolling average reductions will be compared to this reference reduction value. Transect operation will be discontinued when the 12-month rolling average reduction is less than 20% of the reference reduction value, or when the annual average reduction is less than 30 µg/L, whichever occurs first (Appendix C). The 30 µg/L threshold represents approximately 10 to 20 percent of the average plume concentration which exceeds what could be considered normal fluctuations in the plume and above which would be representative of treatment.

5 CONTINGENCY PLAN

5.1 Design Contingency

During system operation, additional biosparge points may be installed if performance monitoring results indicate that the transects do not extend far enough to reduce concentrations of Site-related 1,4-dioxane concentrations along the core of the lower 1,4-dioxane weathered bedrock plume. An additional transect may be considered if the time for downgradient flushing between transects is longer than expected. Additional 1-inch laterals may be installed during system construction to allow for easier expansion of transects in the future, if needed.

5.2 Operating Contingency

The biosparge system will be immediately shut down and MDEQ will be notified if:

- Propane is detected at or above 10% of the LEL in ambient air in or around the treatment area.
- Conditions are observed in weathered bedrock wells that indicate that sparged gases cannot vent (e.g., increasing injection pressures corresponding reduced injection flow rates, sustained water level mounding within 10 feet of the ground surface).

In the event of an unexpected system shutdown, Arcadis will evaluate the available monitoring data to determine the cause of the issue and adapt the operation such that safe operation can resume.

5.3 Contingencies

The system will be designed to be adaptively operated based on performance monitoring completed during the operation of the system. Design contingencies may include:

- Additional biosparge points within a transect;
- Additional transect installation to speed up pore flushing;
- Update system to be in line with the progressing state-of-the science relative to 1,4-dioxane biodegradation; and,
- Shut down and/or increase flow to focus treatment on recalcitrant portions of the system based on performance data.

As stated in Section 1.2, the biosparge system will be operated to remediate the lower 1,4-dioxane plume to reach the point of diminishing returns, stable or decreasing trends of Site related 1,4-dioxane along the core and at the western property boundary, or until the short and long-term objectives have been met.

6 SCHEDULE

The Pre-Design Study operated from January through mid-April 2018. RACER held a public information session in August 2018, at which time public comments on this interim measure were solicited and addressed. RACER met with other agency stakeholders in September 2018 regarding full-scale implementation of the corrective measure. Contractor selection process will begin after MDEQ approves this Work Plan. The contractor selection process will include development of plans and specifications The design will be included as part of a bid package in order to request competitive bids for completion of the work.

The schedule for implementing the system will be determined after a contractor(s) is selected but implementation is targeted to begin in 2019.

7 REFERENCES

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Arcadis 2017b. Approval Request: Lower 1,4-Dioxane Biosparge Pre-Design Study. September 29.

Arcadis 2017c. Revised Interim Groundwater Monitoring Work Plan, RACER Trust Plants 2, 3, & 6, Lansing, Michigan. January 30.

Arcadis 2018. Site Specific Health and Safety Plan. RACER Trust, Lansing Plants 2, 3, and 6. June 1.

United States Geological Survey and National Parks Service. 2000. Geologic Provinces of the United States. Retrieved April 21, 2006 from: www2.nature.ups.gov/geology/usgenpa/province.Vainberg, S., K. McClay, H. Masuda, D. Root, C. Condee, G.L. Zylstra, and R.J. Steffan. 2006. Biodegradation of ether pollutants by Pseudonocardia sp. strain ENV478. Appl. Environ. Microbiol. 2006. 72:5218-522

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Interim Measures Work Plan: Lower 1,4-Dioxane Biosparge

Lansing Industrial Land – Lansing, Michigan

TABLES

TABLE 1
Proposed Sampling Plan
RACER Trust Industrial Land
Lansing, Michigan

Sampling Location	Parameter	Baseline	After Nutrient Addition	During First Year of Operation, then Reduced Frequency Beginning Year 2	Method	Field Measurement or Lab Analysis
Performance Monitoring Wells [1]	Propane	1	-	1/quarter	AM20GAX	Lab Analysis
	1,4-dioxane	1	-	1/quarter	8260B-SIM	Lab Analysis
	TKN	1	1	1/quarter	SM 4500-N(org)/NH	Lab Analysis
	Total phosphorus	1	1	1/quarter	SM 4500-PE	Lab Analysis
	Total organic carbon	1 [3]	-	-	SM5310C	Lab Analysis
	DTW, pH, DO, spec cond, temp, ORP, turb	1	1	1/quarter	Multi-probe	Field Measurement [4]
Perimeter Monitoring Wells [2]	Propane	1	-	1/quarter	AM20GAX	Lab Analysis

Notes

(1) Approximately 16 new performance wells will be installed. Existing monitoring wells will be incorporated into the performance monitoring network as applicable.

(2) Perimeter wells: MW-15-72, MW-16-77, MW-16-75, MW-16-74, MW-16-79, MW-14-61, MW-16-85, MW-13-45, MW-15-73, MW-14-63, MW-14-64, and MW-13-49. Monitoring list will be adjusted as needed based on observations made during full-scale operation.

(3) TOC may be monitored in select wells as needed following sand lens creation to verify radius of influence.

(4) Field measurements recorded using hand held multi-probe.

Sampling plan is based on information known at the time of this Work Plan. Sample parameters, locations and frequency will be re-evaluated routinely during operations. Modifications to the plan will be made by RACER and Arcadis as new information becomes available.

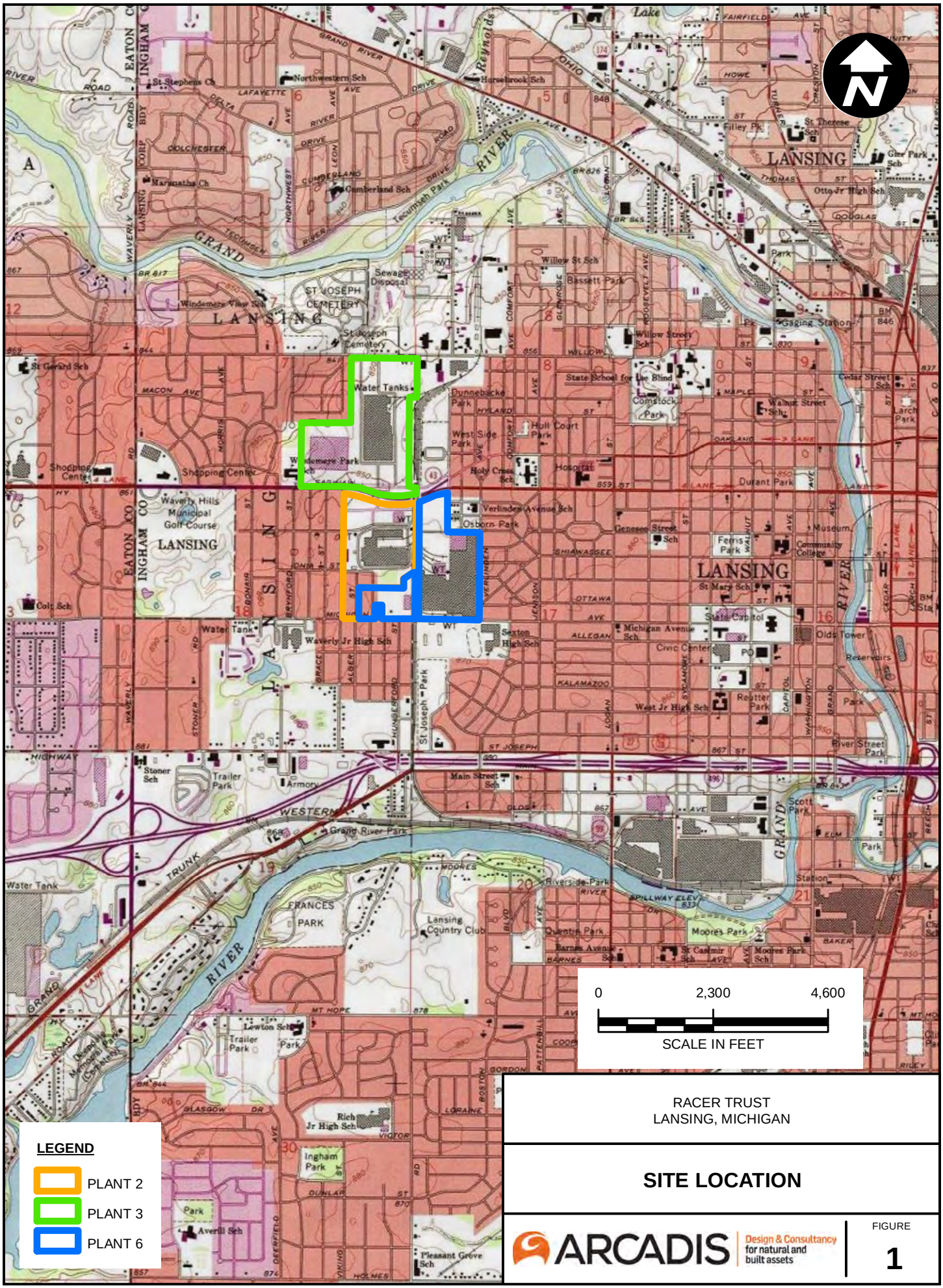
Abbreviations

DO = Dissolved oxygen
DTW = Depth to water
ORP = oxidation reduction potential
spec cond = specific conductance
TKN = total Kjeldahl nitrogen
turb = turbidity
temp = temperature

Interim Measures Work Plan: Lower 1,4-Dioxane Biosparge

Lansing Industrial Land – Lansing, Michigan

FIGURES



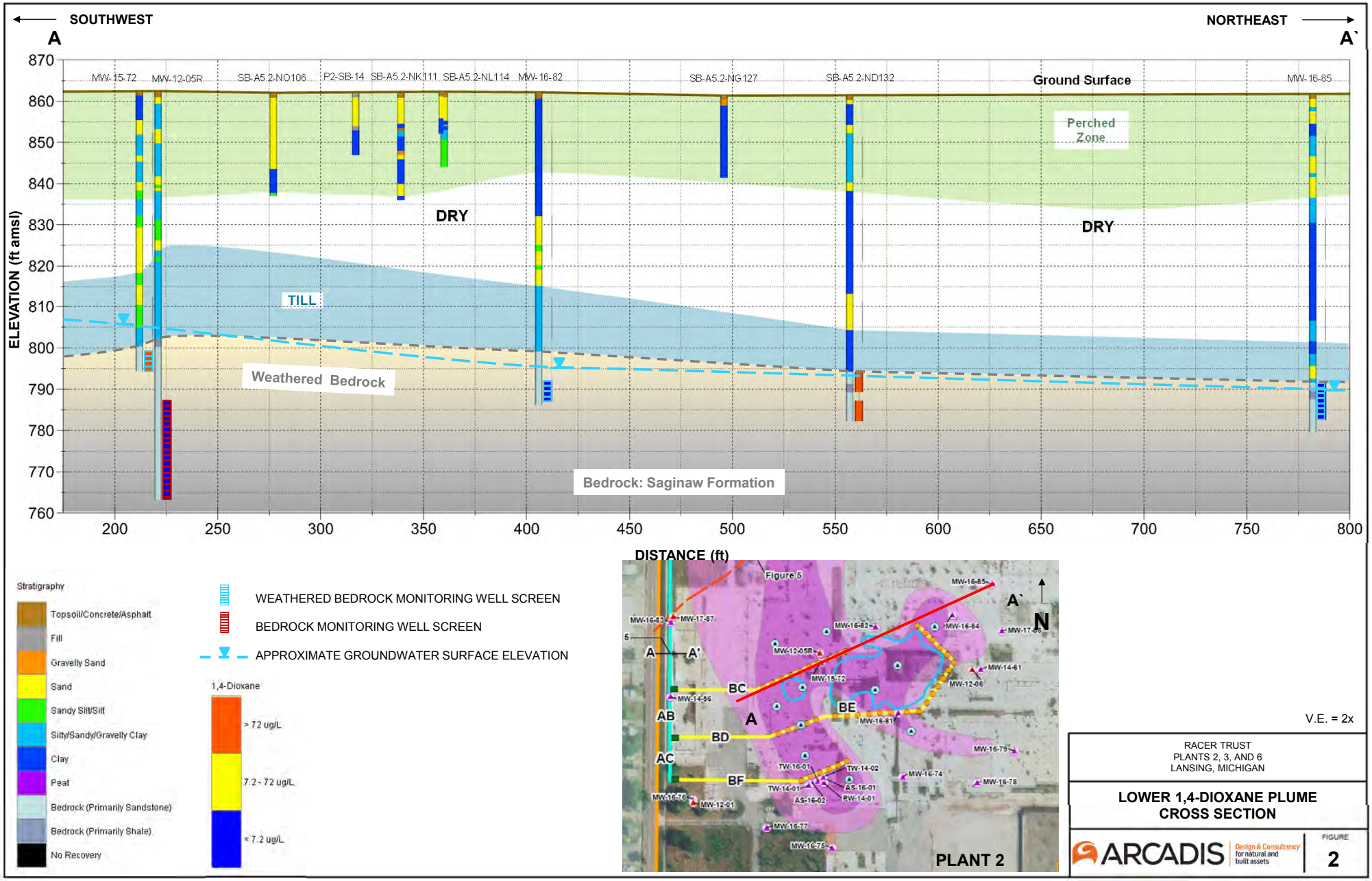
RACER TRUST
LANSING, MICHIGAN

SITE LOCATION

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1

CITY: KNOXVILLE DIV: ENV DB: A.SMITH PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
G:\GIS\Project Files\MotorsLiquidationCompany\Lansing\Docs\Phase 2 RFI Report Figs\FIG 1 - SITE LOCATION.mxd PLOTTED: 5/20/2016 10:51:21 AM BY: dolexa



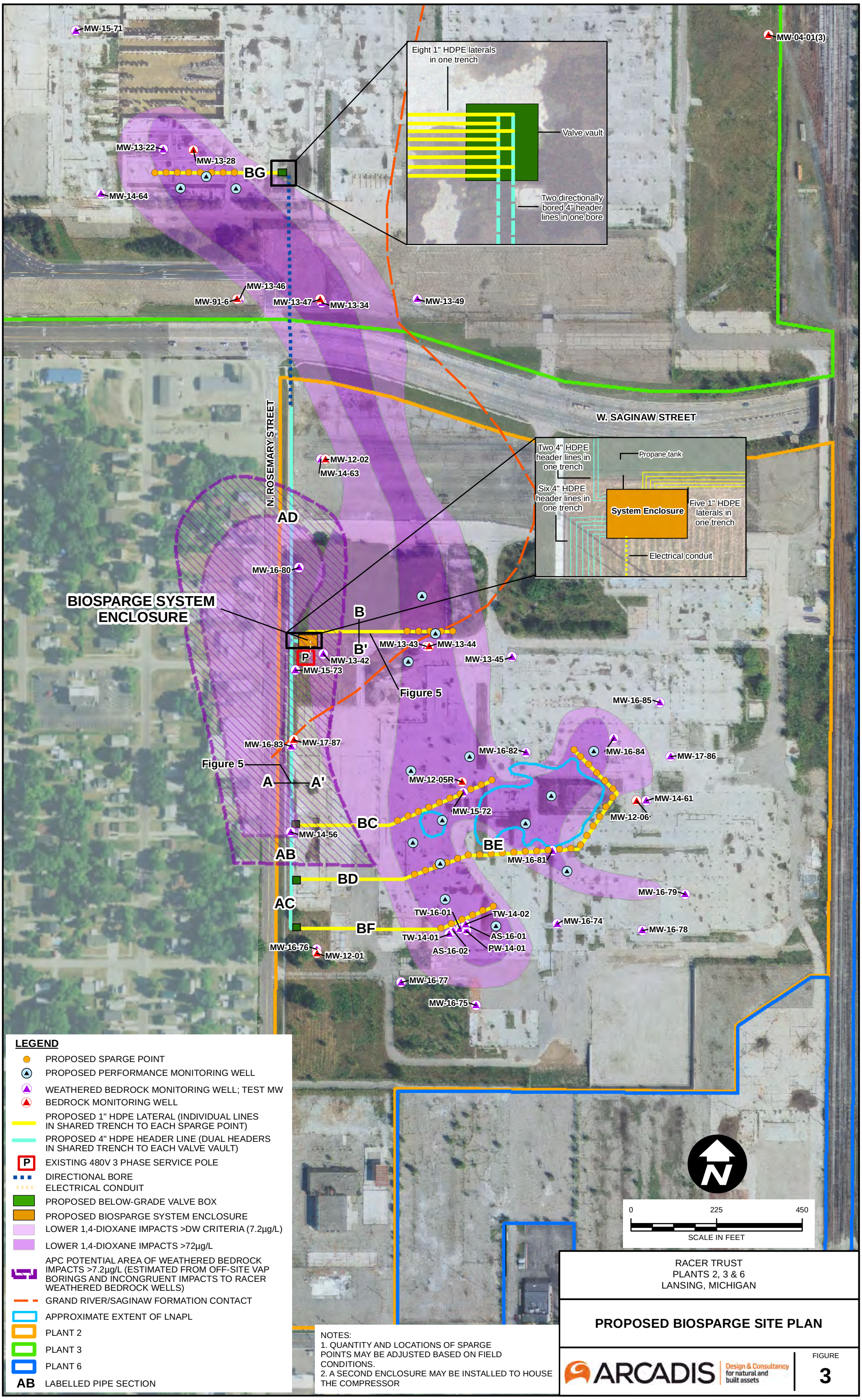
V.E. = 2x

RACER TRUST
PLANTS 2, 3, AND 6
LANSING, MICHIGAN

LOWER 1,4-DIOXANE PLUME CROSS SECTION

ARCADIS Design & Consultancy for natural and built assets

FIGURE 2



LEGEND

- PROPOSED SPARGE POINT
- PROPOSED PERFORMANCE MONITORING WELL
- WEATHERED BEDROCK MONITORING WELL; TEST MW
- BEDROCK MONITORING WELL
- PROPOSED 1" HDPE LATERAL (INDIVIDUAL LINES IN SHARED TRENCH TO EACH SPARGE POINT)
- PROPOSED 4" HDPE HEADER LINE (DUAL HEADERS IN SHARED TRENCH TO EACH VALVE VAULT)
- P — EXISTING 480V 3 PHASE SERVICE POLE
- DIRECTIONAL BORE
- ELECTRICAL CONDUIT
- PROPOSED BELOW-GRADE VALVE BOX
- PROPOSED BIOSPARGE SYSTEM ENCLOSURE
- LOWER 1,4-DIOXANE IMPACTS >DW CRITERIA (7.2µg/L)
- LOWER 1,4-DIOXANE IMPACTS >72µg/L
- APC POTENTIAL AREA OF WEATHERED BEDROCK IMPACTS >7.2µg/L (ESTIMATED FROM OFF-SITE VAP BORINGS AND INCONGRUENT IMPACTS TO RACER WEATHERED BEDROCK WELLS)
- GRAND RIVER/SAGINAW FORMATION CONTACT
- APPROXIMATE EXTENT OF LNAPL
- PLANT 2
- PLANT 3
- PLANT 6
- AB — LABELLED PIPE SECTION

NOTES:
1. QUANTITY AND LOCATIONS OF SPARGE POINTS MAY BE ADJUSTED BASED ON FIELD CONDITIONS.
2. A SECOND ENCLOSURE MAY BE INSTALLED TO HOUSE THE COMPRESSOR

RACER TRUST
PLANTS 2, 3 & 6
LANSING, MICHIGAN

PROPOSED BIOSPARGE SITE PLAN

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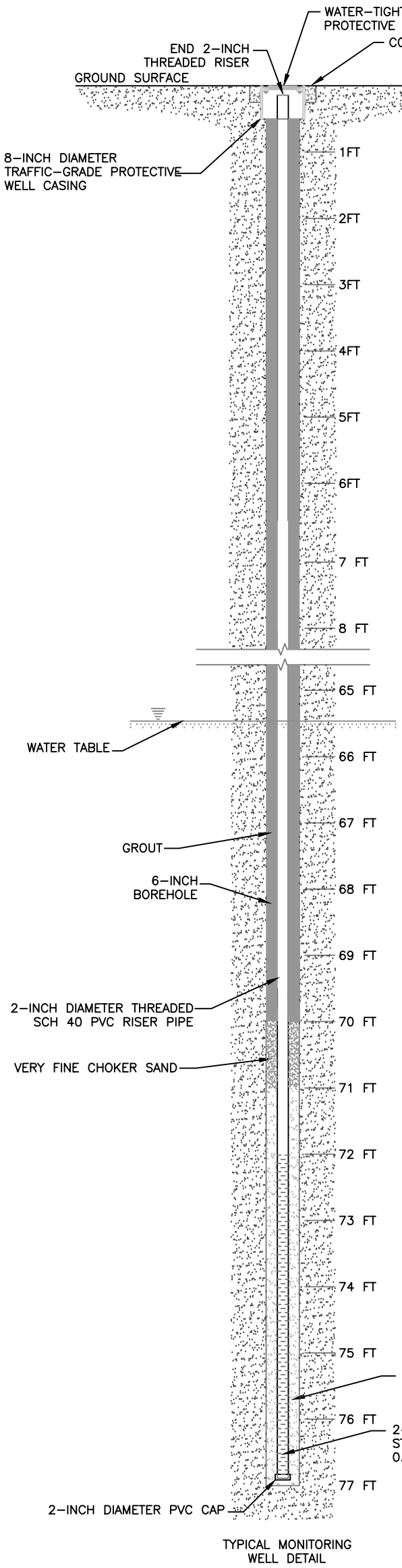
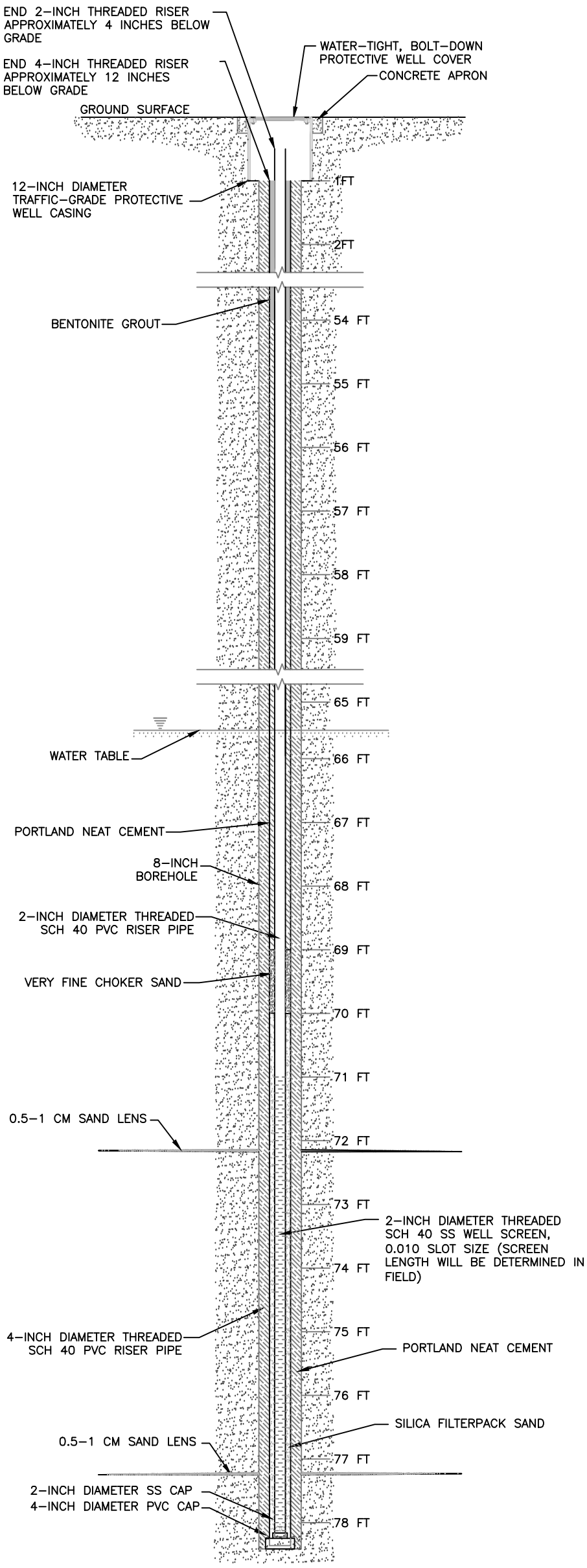
FIGURE 3

CITY: Novi DIV: ENV DB: D. OLEXA PIC: D. KAIDING PM: C. KIKER TM: K. PADRON TR: P. CURRY PROJECT NUMBER: B0064479.2016 COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
Z:\GIS\Projects_ENV\RACER_Lansing\Docs\CMS Report Figures\FIG 3 - Dioxane Biosparging System Layout_20180810.mxd PLOTTED: 10/10/2018 10:48:27 AM BY: akens



TYPICAL MONITORING WELL DETAIL



TYPICAL BIOSPARGE POINT DETAIL

NOTES
1. EXACT DEPTH OF EACH BIOSPARGE POINT AND MONITORING WELL WILL VARY BASED ON THE DEPTH OF THE WEATHERED BEDROCK (APPROXIMATELY 70–90 FEET BGS)
2. SCREEN LENGTH WILL BE DETERMINED IN THE FIELD

LEGEND
CM CENTIMETER
FT FOOT
PVC POLYVINYL CHLORIDE
SCH SCHEDULE
SS STAINLESS STEEL

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LANSING, MICHIGAN

TYPICAL BIOSPARGE POINT AND MONITORING WELL CONSTRUCTION DETAILS

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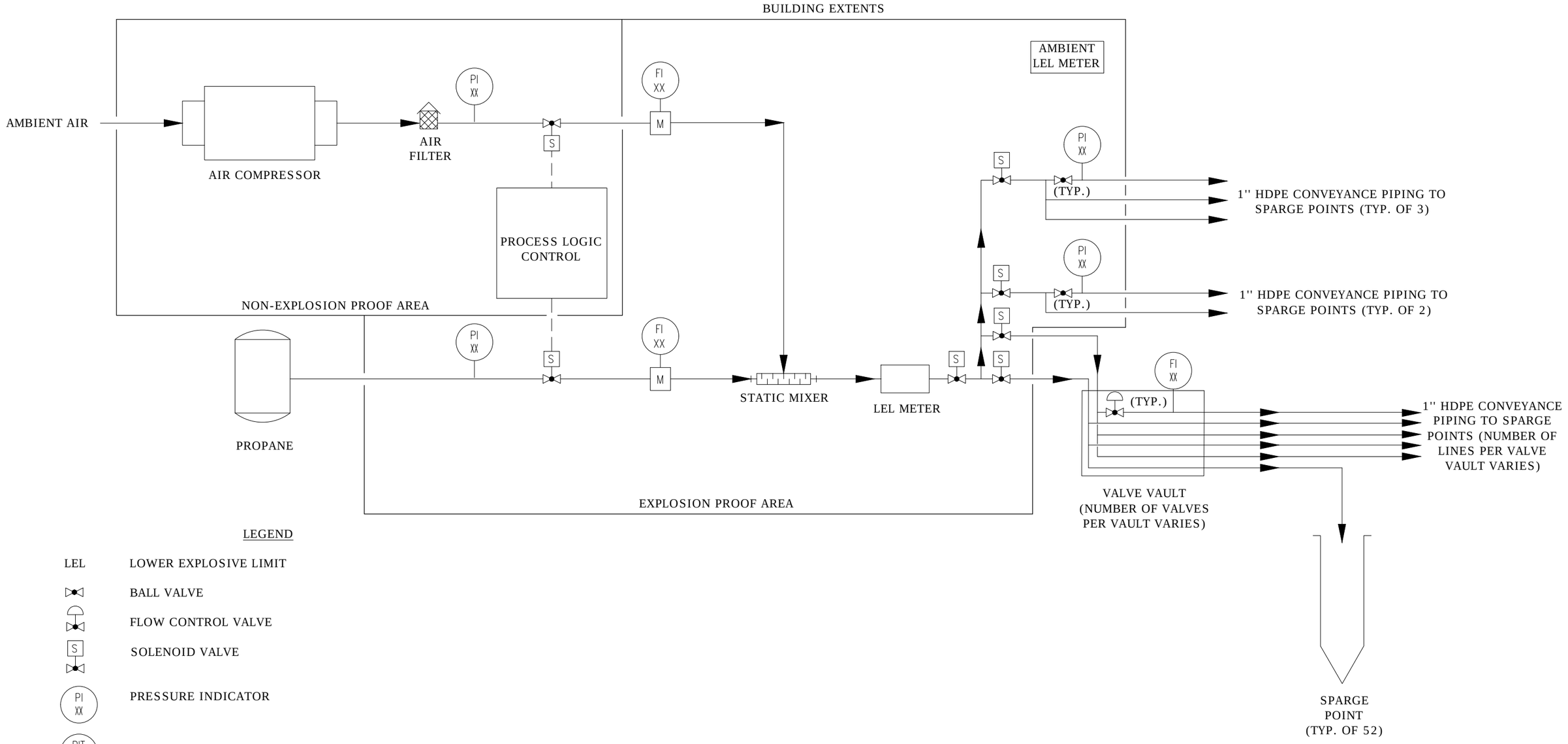
FIGURE 4



LEGEND

LEL	LOWER EXPLOSIVE LIMIT
	BALL VALVE
	FLOW CONTROL VALVE
S	SOLENOID VALVE
PI XX	PRESSURE INDICATOR
PIT XX	PRESSURE TRANSMITTER
FI XX	FLOW METER
FI XX / M	MASS FLOW METER

RACER TRUST
LANSING, MICHIGAN

BIOSPARGE SYSTEM PROCESS FLOW DIAGRAM

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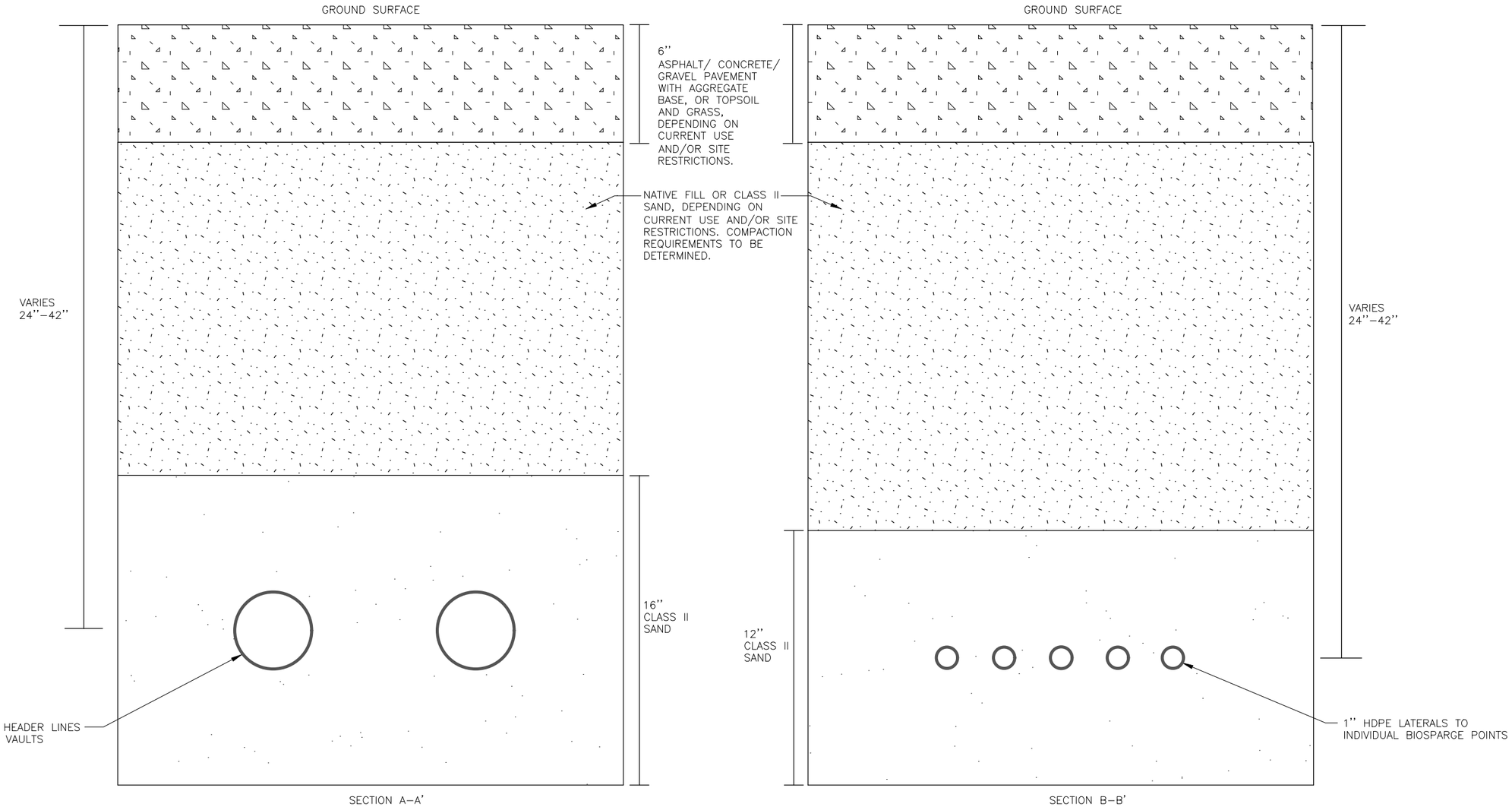
FIGURE 5



CONVEYANCE PIPING SCHEDULE		
PIPE SECTION(2)	NUMBER OF 4'' HDPE HEADER LINES IN TRENCH	NUMBER OF 1'' HDPE LATERALS IN TRENCH
A–A'	6	0
AB	4	0
AC	2	0
AD	2	0
B–B'	0	5
BC	0	21
BD	0	12
BE	0	7
BF	0	6
BG	0	8

NOTES
1. DRAWING IS NOT TO SCALE
2. PIPE SECTION CORRESPONDS TO FIGURE 3 LAYOUT

RACER TRUST
LANSING, MICHIGAN

BIOSPARGE PIPING DETAILS

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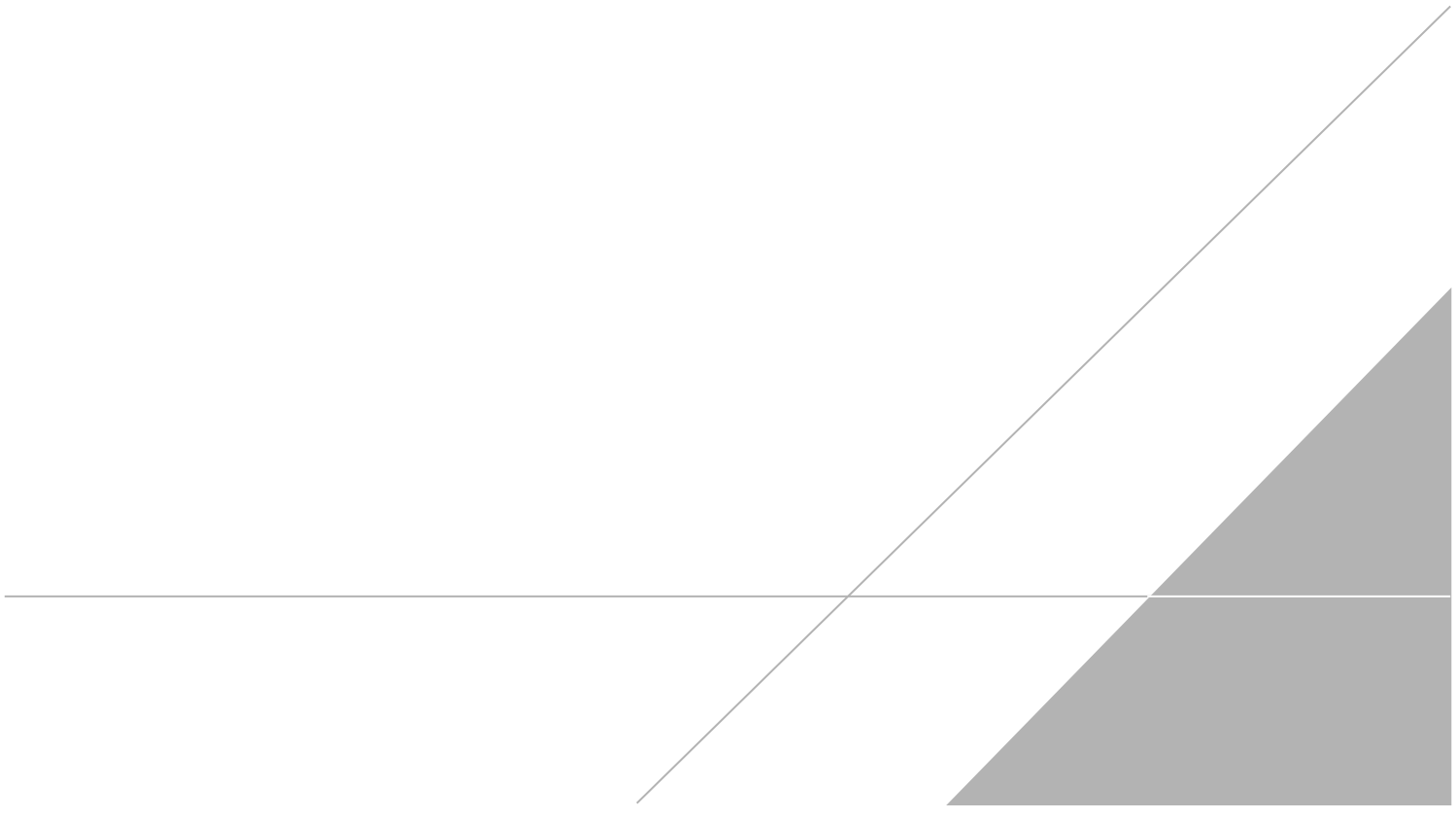
FIGURE
6

Appendix A
Safety Data Sheets



SAFETY DATA SHEET

Propane

Section 1. Identification

GHS product identifier : Propane

Chemical name : propane

Other means of identification : Propyl hydride; n-Propane; Dimethyl methane; Bottled gas; propane in gaseous state; propane liquefied, n-Propane; Dimethylmethane; Freon 290; Liquefied petroleum gas; Lpg; Propyl hydride; R 290; C3H8; UN 1075; UN 1978; A-108; Hydrocarbon propellant.

Product use : Synthetic/Analytical chemistry.

Synonym : Propyl hydride; n-Propane; Dimethyl methane; Bottled gas; propane in gaseous state; propane liquefied, n-Propane; Dimethylmethane; Freon 290; Liquefied petroleum gas; Lpg; Propyl hydride; R 290; C3H8; UN 1075; UN 1978; A-108; Hydrocarbon propellant.

SDS # : 001045

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE GASES - Category 1
GASES UNDER PRESSURE - Liquefied gas

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Extremely flammable gas.
Contains gas under pressure; may explode if heated.
May cause frostbite.
May form explosive mixtures in Air.
May displace oxygen and cause rapid suffocation.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Always keep container in upright position. Approach suspected leak area with caution.

Prevention : Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.

Response : Leaking gas fire: Do not extinguish, unless leak can be stopped safely. Eliminate all ignition sources if safe to do so.

Storage : Protect from sunlight when ambient temperature exceeds 52°C/125°F. Store in a well-ventilated place.

Revision Number: 001.1 **Issue date:** 07/24/2017

1. IDENTIFICATION OF THE SUBSTANCE OR MIXTURE AND OF THE SUPPLIER

Product identifier used on the label: 20 Mule Team Borax

Recommended use of the chemical and restrictions on use: Universal

Name, address and telephone number of the chemical manufacturer:
Henkel Consumer Goods Inc.
7201 E. Henkel Way
Scottsdale, AZ 85255

Telephone: For medical emergencies 1-888-689-9082

CHEMTREC: 1-800-424-9300
Internet: www.henkel-northamerica.com

2. HAZARDS IDENTIFICATION

The hazards described in this Globally Harmonized System Safety Data Sheet (SDS) are not intended for consumers, and does not address consumer use of the product. For information regarding consumer applications of this product, refer to the product label.

Classification of the substance or mixture in accordance with paragraph (d) of §1910.1200

HAZARD CLASS	HAZARD CATEGORY
SKIN IRRITATION	2
EYE IRRITATION	2A
REPRODUCTIVE TOXICITY	2

Signal word, hazard statement(s), symbol(s) and precautionary statement(s) in accordance with paragraph (f) of §1910.1200

Signal word: WARNING

Hazard Statement(s):
Causes skin irritation.
Causes serious eye irritation.
Suspected of damaging fertility or the unborn child.

Symbol(s):

Precautionary Statements:

Prevention:
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Wash thoroughly after handling.
Wear eye and face protection.
Wear protective gloves.
Use personal protective equipment as required.

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

Storage: Store locked up.

Disposal: Dispose of contents and/or container according to Federal, State/Provincial and local governmental regulations.

Hazards not otherwise classified: None known

Classification complies with OSHA Hazard Communication Standard (29 CFR 1910.1200) and is consistent with the provisions of the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

See Section 11 for additional toxicological information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

The following chemicals are classified as health hazards in accordance with paragraph (d) of § 1910.1200.

Chemical Name*	CAS Number (Unique Identifier)	Concentration
Sodium tetraborate decahydrate	1303-96-4	60 - 100 %

*The specific chemical identity and/or exact percentage (concentration) of composition has been withheld because a trade secret is claimed in accordance with paragraph (i) of §1910.1200.

4. FIRST AID MEASURES

Description of necessary measures

Inhalation: Remove from exposure area to fresh air. Treat symptomatically and supportively.

Skin contact: Rinse affected area with large amounts of water until no evidence of product remains. Get medical attention if irritation persists.

Eye contact: Immediately rinse eyes with plenty of water for at least 15 minutes while holding eyelids open. Get medical attention if pain or irritation develops.

Ingestion: Dilution by rinsing the mouth and giving water or milk to drink is generally recommended. Contact physician or local poison control center.

Most important symptoms and effects, both acute and delayed

After eye contact: Moderate to strong irritation of the eyes (redness, swelling, burning, watering eyes), the occurrence of these symptoms may be delayed.

After skin contact: May cause moderate to severe irritation. After Ingestion: Ingestion may cause pain, burning, swelling and redness in the mouth and throat. Nausea and vomiting may occur. After inhalation: Dust may cause mucous membrane irritation with coughing and shortness of breath.

Indication of any immediate medical attention and special treatment needed

After eye contact: Rinse eyes immediately with plenty of water, occasionally lifting upper and lower lids, until no evidence of product remains. After skin contact: Rinse affected area with large amounts of water until no evidence of product remains. After ingestion: May be fatal if swallowed and enters airways. Dilution by rinsing the mouth and giving a glass of water to drink is generally recommended. After inhalation: Remove from exposure area to fresh air. Contact physician or local poison control center.

5. FIRE FIGHTING MEASURES

Suitable (and unsuitable) extinguishing media

Suitable extinguishing media: Extinguish using agent suitable for type of surrounding fire. Product is fire retardant.

Unsuitable extinguishing media: None known

Specific hazards arising from the chemical

Thermal decomposition products may include toxic oxides of sodium and boron.

Special protective equipment and precautions for fire-fighters

In case of fire, wear a full-face positive-pressure self-contained breathing apparatus and protective suit. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Avoid breathing vapors, keep upwind. Isolate area. Keep unnecessary personnel away.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Wear skin, eye and respiratory protection as recommended in Section 8. Stop leak if you can do it without risk. Spills present a slipping hazard. Keep unnecessary personnel away. Ensure clean-up is conducted by trained personnel only. Ventilate spill area if possible. Make sure area is slip-free before re-opening to traffic.

Environmental precautions

Small or household quantities may be disposed in regular domestic trash. For larger quantities check with your local disposal authorities.

Methods and materials for containment and cleaning up

SMALL SPILLS: Sweep or scoop up and place into containers for later disposal. Wash site of spillage thoroughly with water.
LARGE SPILLS: Sweep or scoop up and place into suitable clean, dry containers for reclamation or later disposal. Dispose in suitable waste container. Keep unnecessary people away from spill.

7. HANDLING AND STORAGE

Precautions for safe handling

Do not get in eyes, on skin, on clothing Do not take internally. Use with adequate ventilation.

Conditions for safe storage, including any incompatibilities

Store in original containers in a cool dry area. Storage areas for large quantities (warehouse) should be well ventilated. Keep the containers tightly closed when not in use.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

OSHA permissible exposure limit (PEL), American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available.

Hazardous Component(s)	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Sodium tetraborate decahydrate	2 mg/m3 TWA Inhalable fraction. 6 mg/m3 STEL Inhalable fraction.	None	None	None

Appropriate engineering controls

Provide local exhaust or general dilution ventilation to keep exposure to airborne contaminants below the permissible exposure limits where mists or vapors may be generated.

Individual protection measures

Respiratory: If respiratory protection is required, it must be based on the contamination levels found in the workplace, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

Eye: Safety glasses are required to prevent eye contact where dusty conditions may occur.

Hand/Body: Protective gloves are required where repeated or prolonged skin contact may occur. Protective clothing is required where repeated or prolonged skin contact may occur.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	solid white
Odor:	odourless
Odor threshold:	Not available.
pH:	9.3 Aqueous solution
Melting point/ range:	Not available.
Boiling point/range:	Not available.
Flash point:	Not applicable
Evaporation rate:	Not available.
Flammable/Explosive limits - lower:	Not available.
Flammable/Explosive limits - upper:	Not available.
Vapor pressure:	Not available.
Vapor density:	Not available.
Solubility in water:	Not available.
Partition coefficient (n-octanol/water):	Not available.
Autoignition temperature:	Not available.
Decomposition temperature:	Not available.
Viscosity:	Not available.
VOC content:	Not available.

10. STABILITY AND REACTIVITY

Reactivity: This product may react with strong oxidizing agents.

Chemical stability: Stable under normal ambient temperature (70°F, 21°C) and pressure (1 atm).

Possibility of hazardous reactions: Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

Conditions to avoid: Avoid storing in direct sunlight and avoid extremes of temperature.

Incompatible materials: Strong oxidizers, acids, zirconium.

Hazardous decomposition products: Thermal decomposition products may include toxic oxides of sodium and boron.

11. TOXICOLOGICAL INFORMATION

Likely routes of exposure including symptoms related to characteristics

Inhalation:	Dust may cause mucous membrane irritation with coughing, dryness and sore throat.
Skin contact:	Prolonged and/or repeated skin contact with this product may cause irritation.
Eye contact:	May cause moderate to severe irritation, with possibility of corneal injury if not removed promptly.
Ingestion:	May cause mild gastrointestinal irritation with nausea, vomiting, diarrhea and abdominal pain.
Physical/Chemical:	The product is irritant to skin and mucous membranes.

Other relevant toxicity information: This product is a laundry care product. The use of this product by consumers is safe under normal and reasonable foreseen use.

Numerical measures of toxicity, including delayed and immediate effect

Hazardous Component(s)	LD50s and LC50s	Immediate and Delayed Health Effects
Sodium tetraborate decahydrate	Oral LD50 (RAT) = 396 - 689 mg/kg Oral LD50 (RAT) = 5,660 mg/kg Oral LD50 (RAT) = 396 mg/kg Oral LD50 (RAT) = 5.66 g/kg Dermal LD50 (RABBIT) = > 10,000 mg/kg Inhalation LC50 (RAT, 4 h) = > 0.002 mg/l	Irritant, Reproductive, Skin, Less weight gain and food intake.

Carcinogenicity information

Hazardous Component(s)	NTP Carcinogen	IARC Carcinogen	OSHA Carcinogen
Sodium tetraborate decahydrate	No	No	No

Carcinogenicity	None of the ingredients in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the Occupational Safety and Health Administration (OSHA).
Mutagenicity	None of the ingredients in this product are known to cause mutagenicity.
Toxicity for reproduction	Sodium borate and boric acid interfere with sperm production, damage the testes and interfere with male fertility when given to animals by mouth at high doses.

12. ECOLOGICAL INFORMATION

Aquatic Toxicity:

This product is anticipated to be safe for the environment at concentrations predicted in household settings under normal use conditions. The following toxicity information is available for the hazardous ingredient(s) when used as technical grade and is provided as reference for the occupational settings.

Toxicity to fish:

The aquatic toxicity profile of this product has not been determined.

Toxicity to aquatic invertebrates:

The aquatic toxicity profile of this product has not been determined.

Toxicity to algae:

The aquatic toxicity profile of this product has not been determined.

Persistence and degradability

The persistence and degradability of this product has not been determined.

Bioaccumulative potential

The bioaccumulation potential of this product has not been determined.

Mobility in soil

The mobility of this product (in soil and water) has not been determined.

13. DISPOSAL CONSIDERATIONS

Description of waste residues:

Hazardous waste number:	Not regulated

Safe handling and disposal methods:

Recommended method of disposal:	This product is not a RCRA hazardous waste and can be disposed of in accordance with federal, state and local regulations.
Disposal of uncleaned packages:	Place in trash.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper shipping classification may vary by packaging, properties, and mode of transportation.

U.S. Department of Transportation Ground (49 CFR)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

International Air Transportation (ICAO/IATA)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

Water Transportation (IMO/IMDG)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

15. REGULATORY INFORMATION

Occupational safety and health act: Hazard Communication Standard, 29 CFR 1910.1200(g) Appendix D: The Occupational Safety and Health Administration (OSHA) require that the Safety Data Sheets (SDSs) are readily accessible to employees for all hazardous chemicals in the workplace. Since the use pattern and exposure in the workplace are generally not consistent with those experienced by consumers, this SDS may contain health hazard information not relevant to consumer use.

United States Regulatory Information

TSCA 8 (b) Inventory Status:	All components are listed or are exempt from listing on the Toxic Substances Control Act Inventory.
TSCA 12 (b) Export Notification:	
CERCLA/SARA Section 302 EHS:	None above reporting de minimis.
CERCLA/SARA Section 311/312:	Not available.
CERCLA/SARA Section 313:	None above reporting de minimis.
California Proposition 65:	No California Proposition 65 listed chemicals are known to be present.

Canada Regulatory Information

CEPA DSL/NDSL Status:	All components are listed on or are exempt from listing on the Canadian Domestic Substances List.

16. OTHER INFORMATION

DISCLAIMER: The data contained herein are furnished for information only and are believed to be reliable. However, Henkel Corporation and its affiliates ("Henkel") does not assume responsibility for any results obtained by persons over whose methods Henkel has no control. It is the user's responsibility to determine the suitability of Henkel's products or any production methods mentioned herein for a particular purpose, and to adopt such precautions as may be advisable for the protection of property and persons against any hazards that may be involved in the handling and use of any Henkel's products. In light of the foregoing, Henkel specifically disclaims all warranties, express or implied, including warranties of merchantability and fitness for a particular purpose, arising from sale or use of Henkel's products. Henkel further disclaims any liability for consequential or incidental damages of any kind, including lost profits.

This safety data sheet contains changes from the previous version in sections: New Safety Data Sheet format.

Prepared by: R&D Support Services

Issue date: 07/24/2017

Safety Data Sheet

SECTION 1 – CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: ENV 425 microbial culture

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-hazardous, naturally occurring, non-genetically altered, aerobic 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

Components	%	OSHA PEL	ACGIH TLV	OTHER LIMITS
Non-Hazardous Ingredients	100	N/A	N/A	N/A

ENV 425 culture comprised of microorganism of the genus *Rodococcus ruber.*

SECTION 3 – HAZARDS IDENTIFICATION

There are no known hazardous effects based on available data. The effects of exposure to this material have not been determined. Safe handling of this material on a long-term basis will avoid any possible effect from repetitive acute exposures. Below are possible health effects based on information from similar materials. Individuals hyper allergic to enzymes or other related proteins should not handle.

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 AND EXPLOSION DATA

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

Do not breathe vapor/spray. Avoid contact with skin. Wear suitable protective clothing.
Keep containers tightly closed in a cool, well-ventilated area. The ENV 425 microbial culture 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 air up to the pressure of 15 psi. Do not exceed pressure of 15 psi during transfer of ENV425 microbial culture from kegs. Don't open keg if content of the keg is under pressure.

ENV 425 microbial consortium may be stored for up to 3 weeks at temperature 2-4°C . Avoid freezing.

SECTION 8 – EXPOSURE CONTROLS/PERSONAL PROTECTION

Hand Protection: Rubber or vinyl gloves.

Eye Protection: Safety goggles with side splash shields.

Protective Clothing: Use adequate clothing to prevent skin contact.

Respiratory Protection: Surgical mask.

Ventilation: Provide adequate ventilation to remove odors.

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

SECTION 9 – PHYSICAL/CHEMICAL CHARACTERISTICS

Physical state and appearance: Orange color liquid.

Boiling Point: 100°C (water)

Specific Gravity (H_2O = 1): 0.9 - 1.1

Vapor Pressure @ 25°C: 24 mm Hg (water)

Melting Point: 0°C (water)

Vapor Density: N/A

Evaporation Rate (H_2O = 1): 0.9 - 1.1

Solubility in Water: Soluble

Water Reactive: No

pH: 6.0 - 8.0

SECTION 10 – STABILITY AND REACTIVITY DATA

Stability: Stable

Conditions to Avoid: None

Incompatibility (Materials to Avoid): Water-reactive materials

Hazardous Decomposition Byproducts: None

SECTION 11 – TOXICOLOGICAL INFORMATION

Routes of Entry: Skin, eye contact. Inhalation. Ingestion.

Acute oral toxicity: none known.
Acute inhalation toxicity: none known.
Acute dermal irritation: none known.

SECTION 12 – ECOLOGICAL INFORMATION

Ecotoxicity: none known. This material will degrade in the environment.
BOD5 and COD: N/A

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 ENV 425 culture 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 1020
MSDS Creation Date: 10/06/2003
Last Revised: May 15, 2014

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.

LEB-H MATERIAL SAFETY DATA SHEET

Rantec Corporation, Highway 14, Ranchester, WY 82839

PRODUCT NAME: LEB-H

SECTION 1. PRODUCT IDENTIFICATION & EMERGENCY INFORMATION

TRADE NAME: LEB-H
CHEMICAL NAME: endo-1,4-R-D-mannase
CHEMICAL FAMILY: Enzyme
D.O.T. EMERGENCY PHONE: 1-307-655-9565
ISSUE DATE: 8 June 2010

SECTION 2. HAZARDOUS INGREDIENTS

CAS NO.	**COMPONENT**	**%** RANGE	**ACGIH TLV**	**OSHA PEL**
7647-14-5	Sodium Chloride	14-15	none	none

SECTION 3. PHYSICAL & CHEMICAL PROPERTIES

SPECIFIC GRAVITY: 1.090-1.1 1 0
DENSITY: approx. 9.23 LB/GAL
BOILING POINT: 220 F
FREEZING/MELTING POINT: approx. 14 OF
SOLUBILITY IN WATER: Complete
PERCENT VOLATILES: None
pH: 7.0 - 7.5
FORM: Liquid
COLOR: Light Brown
ODOR: Fermentation
VAPOR PRESSURE. (mm Hg @ F): ND

SECTION 4. FIRE & EXPLOSION HAZARD

FLASH POINT: None
FLAMMABLE LIMITS: **LEL:NA** **UEL:NA**
EXTINGUISHING MEDIA: This product is non-combustible.
FIRE FIGHTING: None
UNUSUAL FIRE HAZARD: None known.

SECTION 5. HAZARD RATING SYSTEM

	HMIS	NFPA 704	KEY
HEALTH	0	0	4 = Severe
FLAMMABILITY	0	0	3 = Serious
REACTIVITY	0	0	2 = Moderate
			1 = Slight
			0 = Minimal

SECTION 6. HEALTH INFORMATION

PRIMARY ROUTE(S) OF ENTRY: Eyes, skin and ingestion.
CARCINOGEN: Not listed in NTP, IARC monographs or OSHA regulated.
THRESHOLD LIMIT VALUE: Not established for the product.

EFFECTS OF EXPOSURE

EYE CONTACT: May cause eye irritation upon direct contact depending on individual sensitivity.
SKIN CONTACT: May produce a drying effect which can cause irritation on prolonged or repeated exposure.
INHALATION: Not expected to pose an inhalation hazard under conditions of normal use.
INGESTION: Ingestion of large quantities may cause vomiting, diarrhea, and prostration.

FIRST AID

EYES: Immediately flush with copious amounts of water for at least 15 minutes while holding eyelids open. If irritation persists, get medical attention.
SKIN: Wash with soap and water. Remove contaminated clothing and launder before reuse. If irritation persists, get medical attention.
INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
INGESTION: **If** victim is conscious, give large quantities of water to dilute. DO NOT induce vomiting. If vomiting occurs spontaneously, keep the victim's head below hips while vomiting. Never give anything by mouth to an unconscious person. Get immediate medical attention.

TOXICITY

ACUTE: ND

CHRONIC: ND

SECTION 7. PERSONAL PROTECTION
HANDS: Wear rubber or neoprene gloves.
EYES: Chemical splash goggles.
RESPIRATORY: None generally required under conditions of normal use.
VENTILATION: None normally required.
OTHER: Emergency eye wash fountains and safety showers should be in the immediate vicinity of any potential exposure. Remove contaminated clothing and launder before reuse.

SECTION 8. REACTIVITY DATA
STABILITY: Stable
CONDITIONS TO AVOID: None known.
HAZARDOUS POLYMERIZATION: **Will** not occur.
DECOMPOSITION PRODUCTS: NA
INCOMPATIBILITY: None known.

SECTION 9. SPILL CONTROL PROCEDURE
SMALL SPILLS: Stop the flow of material. Surround spill to prevent spreading. Absorb with an inert absorbent or pump to salvage vessels. Flush spill area with water. Do not allow material to dry on floor or other surfaces as dust may be irritating.
LARGE SPILLS: Same procedures as above.
DISPOSAL: Dispose of in accordance with all applicable local, state and federal regulations.

SECTION 10. SPECIAL PRECAUTIONS
HANDLING & STORAGE: Store in a cool location from 35 - 77 OF. Do not get in eyes, on skin or clothing. Wash thoroughly after handling. Remove contaminated clothing and launder before reuse. Wear appropriate protective equipment.
PRECAUTIONARY LABEL INFORMATION: CAUTION! Do not get in eyes, on skin or clothing. May cause eye and skin irritation.

SECTION II. REGULATORY INFORMATION

DEPARTMENT OF TRANSPORTATION

D.O.T. SHIPPING NAME: ESA-15, Not Regulated
D.O.T. HAZARD CLASS: None.
UN NUMBER: NA
NA NUMBER: NA

TSCA

All components of this product are listed on the TSCA Inventory.

CERCLA

REPORTABLE QUANTITY (RQ): NA
If the reportable quantity of this product is accidentally spilled, the incident is subject to the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and must be reported to the National Response Center by calling (800) 424-8802.

SARA TITLE III

Under the provisions of the Superfund Amendments and Reauthorization Act of 1986, Section 302-Extremely Hazardous Substances (40CFR355), this product does not contain ingredients listed in Appendix A and B.

Under Sections 311/312 of SARA, this product is classified into the following hazard categories:

NO Immediate (acute) health hazard
NO Delayed (chronic) health hazard
NO Fire hazard
NO Sudden Release of Pressure Hazard
NO Reactive Hazard

This product contains the following Section 313 Reportable Quantities: None

NE = Not Established NA = Not Applicable ND = No Data Available
PREPARED BY: Todd Sanner

MSDS NO.:	**393 9205 4000**	**REV.: 05**
ISSUE DATE:	**05/21/97**	
SUPERSEDES:	**393 9205 4000**	**REV.: 04**
	12/06/96	

Aqualon, a Division of Hercules Incorporated
1313 North Market Street
Wilmington, DE 19894-0001
(302) 594-5000 (24 hrs)

SECTION 1: PRODUCT IDENTIFICATION

PRODUCT NAME: **GALACTASOL® 20H5F1 guar product**

APPEARANCE: powder

COLOR: off-white to pale yellow

ODOR: mild

CASRN: 9000-30-0

CHEMICAL DESCRIPTION: guar gum

HMIS RATINGS

Health hazard: 1 SLIGHT

Flammability hazard: 1 SLIGHT

Reactivity hazard: 0 MINIMAL

SECTION 2: HAZARDOUS COMPONENT INFORMATION

The ingredients in this product are not listed in 29CFR1910, Subpart Z, nor do they appear in "Threshold Limit Values for Chemical Substances and Physical Agents", ACGIH.

If this product is used in a manner that could generate particulates (dust), refer to MSDS Section 8, Recommended Exposure Limits and Personal Protective Equipment.

SECTION 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: *WARNING!*

Static charges generated by emptying package in or near flammable vapors may cause flash fire.
May form flammable dust-air mixtures.
May cause eye irritation by mechanical abrasion.
May cause skin irritation.
Inhalation of dust may cause respiratory tract irritation.
Inhalation of dust may cause respiratory sensitization (allergic response) in susceptible individuals.
Surfaces subject to spills can become slippery.

Refer to Section 5 for Hazardous Combustion Products, and Section 10 for Hazardous Decomposition/Hazardous Polymerization Products.

SECTION 4: FIRST AID PROCEDURES

EYES:

Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get immediate medical attention.

SKIN:

Wash thoroughly with soap and water. Remove contaminated clothing. Thoroughly wash clothing before reuse. Get medical attention if irritation develops or persists.

INHALATION:

Remove to fresh air. Treat any irritation symptomatically. Get immediate medical attention.

INGESTION:

No adverse health effects are expected from accidental ingestion of small amounts of this product. For accidental ingestion of large amounts: If conscious, drink large quantities of water. Induce vomiting. Get immediate medical attention. NEVER give anything by mouth to an unconscious person. NEVER induce vomiting in an unconscious person.

SECTION 5: FIRE HAZARDS

FIRE FIGHTING PROCEDURES:

Wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH approved (or equivalent) and full protective gear when fighting fires involving this product.

EXTINGUISHING MEDIA:

Water spray, dry chemical, foam, carbon dioxide or halon may be used on fires involving this product.

CONDITIONS TO AVOID:

Avoid conditions that generate dust. This product may form flammable dust-air mixtures.

HAZARDOUS COMBUSTION PRODUCTS:

Combustion products include: carbon monoxide, carbon dioxide, and smoke.

AUTOIGNITION TEMPERATURE: 680 ° F 360 ° C

SECTION 6: ACCIDENTAL RELEASE MEASURES

If product is not contaminated, scoop into clean containers for use. If product is contaminated, scoop into containers, and dispose appropriately.
Avoid wetting spills. Wet spills become very slippery. Apply absorbent to wet spills and sweep up for disposal.

In case of accidental spill or release, refer to Section 8, Personal Protective Equipment and General Hygiene Practices.

SECTION 7: HANDLING AND STORAGE

GENERAL MEASURES:

Ground all equipment.
Blanket vessel with inert gas when emptying bags where flammable vapors may be present.
Ground operator and pour material slowly into conductive, grounded chute.

Store in a cool, dry place: approximately 68°F (20°C).
Store in a cool, dry, well ventilated area.

MATERIALS OR CONDITIONS TO AVOID:

Do not store near flammable materials.

Keep away from heat, flame, sparks and other ignition sources.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

GENERAL HYGIENIC PRACTICES:

Avoid contact with eyes, skin, and clothing.
Avoid breathing dust, vapor or mist.
Wash thoroughly after handling, and before eating, drinking or smoking.
Avoid contamination of food, beverages, or smoking materials.

RECOMMENDED EXPOSURE LIMITS:

PARTICULATES (dust): If used under conditions that generate particulates (dust), the OSHA TWA of 5 mg/m3 respirable fraction (15 mg/m3 total), and ACGIH TLV-TWA of 3 mg/m3 respirable fraction (10 mg/m3 total) should be observed.

PERSONAL PROTECTIVE EQUIPMENT:

Safety glasses
Impervious gloves
Appropriate protective clothing
Appropriate respiratory protection is required when exposure to airborne contaminants may exceed acceptable limits. Respirators should be selected and used in accordance with OSHA, Subpart I (29 CFR 1910.134) and manufacturer's recommendations.

WORK PRACTICES AND ENGINEERING CONTROLS:

Keep away from ignition sources. May form flammable dust-air mixtures.
Eyewash fountains and safety showers should be easily accessible.
Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Discharge from the ventilation system should comply with applicable air pollution control regulations.
Clean up spills immediately. Keep floors clean and dry.

PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE:

Eliminate ignition sources and prevent build-up of static electrical charges.
Completely isolate and thoroughly clean all equipment, piping, or vessels before beginning maintenance or repairs.
Keep area clean. Product will burn.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

pH:	4.0-6.0
Volatile (Wt.), %:	10.0
Solubility in Water:	limited by viscosity
Specific Gravity:	0.6
Viscosity (Centipoise):	60 CPS (2%, Brookfield) RT

SECTION 10: STABILITY AND REACTIVITY

GENERAL STABILITY CONSIDERATIONS:

Stable under recommended handling and storage conditions.

INCOMPATIBLE MATERIALS:

None known

HAZARDOUS DECOMPOSITION PRODUCTS:

None anticipated under normal or recommended handling and storage conditions.

HAZARDOUS POLYMERIZATION:

Not anticipated under normal or recommended handling and storage conditions.

SECTION 11: TOXICOLOGICAL INFORMATION

REPORTED HUMAN EFFECTS:

Reported to cause respiratory sensitization (allergic reaction) in susceptible individuals.

REPORTED ANIMAL EFFECTS:

No animal toxicity studies have been carried out with this product. Similar material: Not an eye or skin irritant to animals. Not toxic by OSHA/ANSI criteria based on acute animal oral testing of this or a similar product (LD50 >500 mg/kg).

CARCINOGENICITY INFORMATION:

Not listed as a carcinogen by NTP. Not regulated as a carcinogen by OSHA. Not evaluated by IARC.

MUTAGENICITY/GENOTOXICITY INFORMATION:

No mutagenicity studies have been carried out with this product.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICITY:

No ecological studies have been carried out with this product.

SECTION 13: DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD:

Incineration in accordance with applicable regulations is the recommended disposal method. Landfilling in a permitted solid or hazardous waste facility, meeting technical regulatory requirements, is a suitable alternative. Wastewater containing this product can be considered for treatment in an acclimated biological treatment system.

SECTION 14: TRANSPORTATION INFORMATION

For information regarding transportation of this product, please contact Hercules Transportation at (302) 594-7356.

SECTION 15: REGULATORY INFORMATION

CHEMICAL INVENTORIES:

U. S. TSCA Status:	Included on TSCA Inventory.
European EINECS Status:	Included on EINECS list.
Canadian CEPA Status:	Included on DSL Inventory.
Korean KECL Status:	Included on KECL Inventory.

SARA TITLE III

Sections 302 and 304:

This product is not an Extremely Hazardous Substance subject to reporting under 40CFR355.

Sections 311 and 312:

NHH: Not a health hazard
HC-3: Fire hazard

Section 313:

This product does not contain any chemicals subject to reporting under Section 313 of Title III of the Superfund Amendments and Reauthorization Act and 40CFR372.

CERCLA

This product does not contain any chemicals subject to reporting as a CERCLA Hazardous Substance under 40CFR302.4.

RCRA

This product is not a hazardous waste as listed in 40CFR261.33. It does not exhibit any of the hazardous characteristics listed in 40CFR261, Subpart C.

SECTION 16: OTHER INFORMATION

LIST OF ACRONYMS:
ACGIH: American Conference of Governmental Industrial Hygienists
AICS: Australian Inventory of Chemical Substances
AIHA WEEL: American Industrial Hygienists Association - Workplace Environmental Exposure Level
ANSI: American National Standards Institute
C: Ceiling
CASRN: Chemical Abstracts Service Registry Number
CERCLA: Comprehensive Emergency Response, Compensation and Liability Act
DSL: Domestic Substances List (Canadian)
EINECS: European Inventory of Existing Commercial Chemical Substances
HMIS: Hazardous Materials Identification System
IARC: International Agency for Research on Cancer
MITI: Ministry of International Trade and Industry (Japanese)
N/A: Not Applicable
NDSL: Non-domestic Substances List (Canadian)
NOR: Not Otherwise Regulated
NTP: National Toxicology Program
OSHA: Occupational Safety and Health Administration
PEL: OSHA Permissible Exposure Limit
RCRA: Resource Conservation and Recovery Act
RQ: Reportable Quantity
SARA: Superfund Amendment Reauthorization Act
STEL: Short-Term Exposure Limit
TLV: Threshold Limit Values (registered trademark of ACGIH)
TPQ: Threshold Planning Quantity
TSCA: Toxic Substances Control Act
TWA: Time Weighted Average

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

1.1. Product identifier

Product form	:	Substance
Substance name	:	(DAP) Diammonium phosphate
Product code	:	DAP, DAPFR,DAPOS, DAPLG
CAS No.	:	7783-28-0
Formula	:	$(NH_4)_2HPO_4$
Synonyms	:	Ammonium phosphate, dibasic / Diammonium hydrogenorthophosphate / Phosphoric acid, diammonium salt / Diammonium hydrogenphosphate / Ammonium phosphate dibasic / Diammonium hydrogen phosphate / Diammonium hydrogen orthophosphate / Phosphoric acid, ammonium salt (1:2) / DIAMMONIUM PHOSPHATE / DAP
Product group	:	Commercial product
Other means of identification	:	DAP, DAPLG

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/preparation	:	Agricultural chemical

1.3. Details of the supplier of the safety data sheet

PCS Sales (USA), Inc.
1101 Skokie Blvd.
Suite 400
Northbrook, IL 60062
T 800-241-6908 / 847-849-4200

Suite 500
122 1st Avenue South
Saskatoon, Saskatchewan Canada S7K7G3
T 800-667-0403 (Canada) / 800-667-3930 (USA)

SDS@PotashCorp.com - www.PotashCorp.com

1.4. Emergency telephone number

Emergency number	:	800-424-9300 CHEMTREC

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

GHS-US classification

Skin Irrit. 2	H315
Eye Irrit. 2B	H320
STOT SE 3	H335
Aquatic, Acute 2	H401

Full text of H-phrases: see section 16

2.2. Label elements

GHS-US labelling

Hazard pictograms (GHS-US) :

GHS07

Signal word (GHS-US) : Warning

Hazard statements (GHS-US) : H315 - Causes skin irritation
H320 - Causes eye irritation
H335 - May cause respiratory irritation
H401 - Toxic to aquatic life.

Precautionary statements (GHS-US) : P261 - Avoid breathing dust
P264 - Wash hands thoroughly after handling
P271 - Use only outdoors or in a well-ventilated area
P273 – Avoid release to the environment.
P280 - Wear eye protection, face protection, protective clothing, protective gloves
P302+P352 - IF ON SKIN: Wash with plenty of water
P304+P340 - IF INHALED: Remove person to fresh air and keep comfortable for breathing
P305+P351+P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P312 - Call a POISON CENTER/doctor if you feel unwell
P332+P313 - If skin irritation occurs: Get medical advice/attention
P337+P313 - If eye irritation persists: Get medical advice/attention
P362 - Take off contaminated clothing
P403+P233 - Store in a well-ventilated place. Keep container tightly closed
P405 - Store locked up
P501 - Dispose of contents/container according to local, regional, national, and international regulations

2.3. Other hazards

Hazardous to the aquatic environment.

No additional information available

SECTION 3: Composition/information on ingredients

3.1. Substances

Substance type : Mono-constituent

Name	Product identifier	%	GHS-US classification
(DAP) Diammonium phosphate (as P_2O_5) (Main constituent)	(CAS No.) 7783-28-0	46	Skin Irrit. 2, H315 Eye Irrit. 2B, H320 STOT SE 3, H335

Name	Product identifier	%	GHS-US classification
Total Nitrogen, as N**		18	
Fluorides, as F		1	

**Product contains diammmonium phosphate as essential ingredient with small amounts of monoammonium phosphate, ammonium sulfate, urea, and aluminum/calcium/iron/magnesium compounds.

Full text of H-phrases: see section 16

3.2. Mixtures

Not applicable

SECTION 4: First aid measures

4.1. Description of first aid measures

First-aid measures general : If medical advice is needed, have product container or label at hand.

First-aid measures after inhalation : If inhaled, remove to fresh air and keep at rest in a position comfortable for breathing. Give oxygen or artificial respiration if necessary. Obtain medical attention if breathing difficulty persists.

First-aid measures after skin contact : Wash skin thoroughly with mild soap and water. Obtain medical attention if irritation develops or persists.

First-aid measures after eye contact : Immediately rinse with water for a prolonged period while holding the eyelids wide open. Obtain medical attention if irritation develops or persists.

First-aid measures after ingestion : Do not induce vomiting. Seek medical attention if a large amount is swallowed. Get medical advice and attention if you feel unwell. Drink large amounts of water (or milk if available) to dilute stomach contents. Ingestion of small quantifies in unlikely to cause toxic effect. Large quantities may give rise to gastro-intestinal disorders.

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

Symptoms/injuries : Irritation to eyes, skin and respiratory tract.

Symptoms/injuries after inhalation : Difficulty in breathing. Dry/sore throat. Symptoms may be delayed.

Symptoms/injuries after skin contact : May cause skin irritation.

Symptoms/injuries after eye contact : May cause eye irritation.

Symptoms/injuries after ingestion : If a large quantity has been ingested : Abdominal pain. Diarrhea. Nausea. Vomiting.

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 : Chemical type foam, Carbon Dioxide (CO_2), dry chemical, water fog.

Unsuitable extinguishing media : None known.

5.2. Special hazards arising from the substance or mixture

Fire hazard : Under conditions of fire this material may produce: Ammonia.

Explosion hazard : Product is not explosive.

Reactivity : Stable at ambient temperature and under normal conditions of use.

5.3. Advice for firefighters

Firefighting instructions : Keep upwind. Under conditions of fire this material may produce: Ammonia.

Protection during firefighting : Wear full fire-fighting turn-out gear (full Bunker gear) and respiratory protection (SCBA).

Other information : Do not allow run-off from fire fighting to enter drains or water courses.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

General measures : Do not breathe fumes from fires or vapours from decomposition.

6.1.1. For non-emergency personnel

Protective equipment : Wear suitable protective clothing, gloves and eye/face protection.

Emergency procedures : Collect as any solid. Ventilate area.

6.1.2. For emergency responders

Protective equipment : Wear suitable protective clothing, gloves and eye/face protection.

Emergency procedures : If possible, stop flow of product. Contain and collect as any solid. Ventilate area.

6.2. Environmental precautions

If spill could potentially enter any waterway, including intermittent dry creeks, contact the U.S. COAST GUARD NATIONAL RESPONSE CENTER at 800-424-8802. In case of accident or road spill notify CHEMTREC at 800-424-9300. In other countries call CHEMTREC at (International code) +1-703-527-3887.

6.3. Methods and material for containment and cleaning up

For containment : If contaminated with other materials, contain and collect as any solid in suitable containers. Do not allow into drains or water courses or dispose of where ground or surface waters may be affected. Prevent large quantities from contacting vegetation.

Methods for cleaning up : Recover the product by vacuuming, shoveling or sweeping and place in appropriate container to be disposed at an appropriate disposal facility according to current applicable laws and regulations and product characteristics at the time of disposal. Provide adequate ventilation. Avoid generation of dust during clean-up of spills. If uncontaminated, recover and reuse product. Practice good housekeeping – spillage can be slippery on smooth surface either wet or dry.

6.4. Reference to other sections

No additional information available

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Additional hazards when processed : When heated, material emits irritating fumes.

Precautions for safe handling : Handle in accordance with good industrial hygiene and safety procedures. Avoid contact with skin and eyes. Do not eat, drink or smoke when using this product.

Hygiene measures : Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions : Store tightly closed in a dry, cool and well-ventilated place. Protect from moisture.

Incompatible materials : Alkalis and caustic products; strong acids; copper and its alloys.

7.3. Specific end use(s)

Agricultural chemical

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Diammonium Phosphate (7783-28-0) as P_2O_5		
USA ACGIH	ACGIH TWA (mg/m³)	10 mg/m^3 – inhalable fraction 3 mg/m^3 – respirable fraction
USA OSHA	OSHA PEL (TWA) (mg/m3)	15 mg/m^3 – particulate 5 mg/m^3 – respirable

Fluorides		
USA ACGIH	ACGIH TWA (mg/m³)	2.5 mg/ m^3
USA OSHA	OSHA PEL (TWA) (mg/m3)	2.5 mg/ m^3

8.2. Exposure controls

Appropriate engineering controls : Ensure adequate ventilation, especially in confined areas. Avoid high dust concentration.

Personal protective equipment : Gloves. Safety glasses. Protective clothing.

Hand protection : Impermeable protective gloves.

Eye protection : Protective goggles.

Skin and body protection : Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure. Wear suitable protective clothing. Wash contaminated clothing before reuse. Handle in accordance with good industrial hygiene and safety practice.

Respiratory protection	: Wear NIOSH approved respiratory protective equipment when exposure exceeds the OSHA nuisance dust standard of 15 mg/m^3 or the ACGIH nuisance dust limit of 10 mg/m^3 for the eight hour time weighted average. When stored in closed area, a self-contained breathing apparatus is required to protect against ammonia gas.
Environmental exposure controls	: Ensure adequate ventilation, especially in confined areas.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state	: Solid
Appearance	: Granular solid
Molecular mass	: 132.06 g/mol
Colour	: Gray to brownish black
Odour	: Ammonia
Odour threshold	: No data available
pH	: 8.0 (conc: 1 % at 20 °C (solution)
Relative evaporation rate (butylacetate=1)	: No data available
Melting point	: 155 °C (302°F) (decomposes)
Freezing point	: No data available
Boiling point	: Decomposes
Flash point	: Not applicable
Self ignition temperature	: Not flammable
Decomposition temperature	: No data available
Flammability (solid, gas)	: Not flammable
Vapour pressure	: < 1 mm Hg (at 20 °C)
Relative vapour density at 20 °C	: No data available
Relative density	: No data available
Density	: 1.619 g/cm³ (at 20 °C)
Bulk Density	: 58-61 lb/ft3 (loose) 60-67 lb/ft3 (tamped)
Solubility	: Water: 588 g/l (at 20 °C)
Log Pow	: No data available. Based on water solubility it is expected that the log P_{ow} would be very low.
Log Kow	: No data available
Viscosity	: No data available
Explosive properties	: Not explosive
Oxidising properties	: No oxidizing properties
Explosive limits	: No data available

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

Stable at ambient temperature and under normal conditions of use.

10.2. Chemical stability

Stable at standard temperature and pressure.

10.3. Possibility of hazardous reactions

Hazardous polymerization will not occur.

10.4. Conditions to avoid

Welding or hot work on equipment or plant which may have contained fertilizer should not be done without first washing thoroughly to remove all fertilizer.

10.5. Incompatible materials

Alkalis and caustic products ; strong acids; copper and its alloys.

10.6. Hazardous decomposition products

Ammonia is released upon reaction with strong bases or from thermal decomposition.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Acute toxicity : Not classified

(DAP) Diammonium phosphate (7783-28-0)	
LD50 oral rat	6500 mg/kg
LD50 dermal rabbit	> 7950 mg/kg
Additional information	This compound is listed by the FDA as generally recognized as safe (GRAS) and may be used as a food additive, for both human food and ruminant feed, according to prescribed conditions.

Skin corrosion/irritation : Causes skin irritation.
pH: 8.0 (conc: 1 % at 20 °C (solution)

Serious eye damage/irritation : Causes eye irritation.
pH: 8.0 (conc: 1 % at 20 °C (solution)

Respiratory or skin sensitisation : Not classified

Germ cell mutagenicity : OECD 471: Bacterial reverse mutation assay, S. typhimurium: Negative
OECD 473: Chromosome aberration test, Chinese hamster ovaries: Negative

Carcinogenicity : Not classified

Reproductive toxicity : Not classified. OECD 422: NOAEL, Rat = 1,500 mg/kg/day

Specific target organ toxicity (single exposure) : May cause respiratory irritation.

Specific target organ toxicity (repeated exposure) : Not classified

(DAP) Diammonium phosphate (7783-28-0)	
NOAEL (oral,rat,90 days)	250 mg/kg bodyweight/day OECD Guideline 422

Aspiration hazard : Not classified

SECTION 12: Ecological information

12.1. Toxicity

Ecotoxicity:	**EPA Ecological Toxicity rating :**	Slightly toxic to practically non-toxic to aquatic organisms based on the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) acute toxicity ratings.
	Acute Toxicity to Fish:	(Coho salmon, Chinook salmon, Rainbow trout, Bluegill, Large mouth
	Chronic Toxicity to Fish:	No data available
	Acute Toxicity to Aquatic Invertebrates:	(Amphipod) 96-hr: LC_{50} = 40-52 mg/L; (Snails, worm) 96-hr: LC_{50} = 1,005 - 2,472 mg/L.
	Chronic Toxicity to Aquatic Invertebrates:	No data available
	Toxicity to Aquatic Plants:	(*Selenastrum capricornutum*) 72-hr: NOEC (stimulation) = 3.57 mg DAP/L; NOEC (toxicity) = 97.1 mg DAP/L.
	Toxicity to Bacteria:	No data available
	Toxicity to Soil Dwelling Organisms:	No data available
	Toxicity to Terrestrial Plants:	No data available
Environmental Fate:	**Stability in Water:**	Stable
	Stability in Soil:	Stable
	Transport and Distribution:	Calculated, fugacity level III: 6.5 x 10^{-15} to air, 45.3% to water, 54.6% to soil, 0.0755% to sediment. Phosphates, whether water or citrate soluble, are translocated in the soil only over very short periods and are then immobilized.
Toxicity:	Inorganic phosphates have the potential to increase the growth of freshwater algae, whose eventual death will	
Degradation Products:	**Biodegradation:**	The Phosphorus cycle is well understood. Phosphates are converted to calcium or iron/aluminum phosphates or are incorporated with the organic soil matter.
	Photodegradation:	No data available

SECTION 13: Disposal considerations

13.1. Waste treatment methods

Sewage disposal recommendations : This material is hazardous to the aquatic environment. Keep out of sewers and waterways.

Waste disposal recommendations : Place in an appropriate container and dispose of the contaminated material at a licensed site.

Additional information : Dispose of waste material in accordance with all local, regional, national, and international regulations.

SECTION 14: Transport information

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

14.1. UN number

No dangerous good in sense of transport regulations.

14.2. UN proper shipping name

Not applicable

14.2 Additional information

Other information : No supplementary information available.

Overland transport

No additional information available

Transport by sea

No additional information available

Air transport

No additional information available

SECTION 15: Regulatory information

15.1. US Federal regulations

(DAP) Diammonium phosphate (7783-28-0)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory	
SARA Section 311/312 Hazard Classes	Immediate (acute) health hazard

15.2. US State regulations

No additional information available

15.3. Canadian regulations

Diammonium phosphate (7783-28-0)	
Listed on the Canadian DSL (Domestic Sustances List) inventory.	
WHMIS Classification	Uncontrolled product according to WHMIS classification criteria

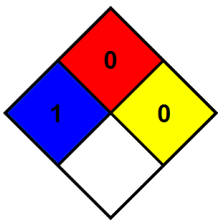
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

SECTION 16: Other information

NFPA health hazard : 1 - Exposure could cause irritation but only minor residual injury even if no treatment is given.

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.



Full text of H- phrases:

Eye Irrit. 2	Serious eye damage/eye irritation Category 2
Skin Irrit. 2	skin corrosion/irritation Category 2
STOT SE 3	H335 – May cause respiratory irritation.
H315	Causes skin irritation
H319	Causes serious eye irritation

Previous PotashCorp MSDS Number : MSDS 4 – Diammonium Phosphate (DAP)

SDS US (GHS HazCom 2012)

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Section 2. Hazards identification

Disposal : Not applicable.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : propane

Other means of identification : Propyl hydride; n-Propane; Dimethyl methane; Bottled gas; propane in gaseous state; propane liquefied, n-Propane; Dimethylmethane; Freon 290; Liquefied petroleum gas; Lpg; Propyl hydride; R 290; C3H8; UN 1075; UN 1978; A-108; Hydrocarbon propellant.

CAS number/other identifiers

CAS number : 74-98-6

Product code : 001045

Ingredient name	%	CAS number
Propane	100	74-98-6

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Wash contaminated skin with soap and water. Remove contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Section 4. First aid measures

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Extremely flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. If involved in fire, shut off flow immediately if it can be done without risk. If this is impossible, withdraw from area and allow fire to burn. Fight fire from protected location or maximum possible distance. Eliminate all ignition sources if safe to do so.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : Accidental releases pose a serious fire or explosion hazard. No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.

Section 6. Accidental release measures

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid contact with eyes, skin and clothing. Avoid breathing gas. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Empty containers retain product residue and can be hazardous. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Eliminate all ignition sources. Keep container tightly closed and sealed until ready for use. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Propane	**NIOSH REL (United States, 10/2013).** TWA: 1800 mg/m³ 10 hours. TWA: 1000 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 1800 mg/m³ 8 hours. TWA: 1000 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** TWA: 1800 mg/m³ 8 hours. TWA: 1000 ppm 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Section 8. Exposure controls/personal protection

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas. [Liquefied compressed gas.]

Color : Colorless.

Molecular weight : 44.11 g/mole

Molecular formula : C3-H8

Boiling/condensation point : -161.48°C (-258.7°F)

Melting/freezing point : -187.6°C (-305.7°F)

Critical temperature : 96.55°C (205.8°F)

Odor : Odorless.BUT MAY HAVE SKUNK ODOR ADDED.

Odor threshold : Not available.

pH : Not available.

Flash point : Closed cup: -104°C (-155.2°F)
Open cup: -104°C (-155.2°F)

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Extremely flammable in the presence of the following materials or conditions: open flames, sparks and static discharge and oxidizing materials.

Lower and upper explosive (flammable) limits : Lower: 1.8%
Upper: 8.4%

Vapor pressure : 109 (psig)

Vapor density : 1.6 (Air = 1)

Section 9. Physical and chemical properties

Specific Volume (ft ^{3}/lb) : 8.6206

Gas Density (lb/ft ^{3}) : 0.116 (25°C / 77 to °F)

Relative density : Not applicable.

Solubility : Not available.

Solubility in water : 0.0244 g/l

Partition coefficient: n-octanol/water : 1.09

Auto-ignition temperature : 287°C (548.6°F)

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not applicable.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.

Incompatible materials : Oxidizers

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

IDLH : 2100 ppm

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Section 11. Toxicological information

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
Propane	1.09	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1978	UN1978	UN1978	UN1978	UN1978
UN proper shipping name	PROPANE	PROPANE	PROPANE	PROPANE	PROPANE
Transport hazard class(es)	2.1 	2.1 	2.1 	2.1 	2.1 
Packing group	-	-	-	-	-
Environment	No.	No.	No.	No.	No.
Additional information	**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: Forbidden. **Cargo aircraft** Quantity limitation: 150 kg **Special provisions** 19, T50	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2). **Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000	-	-	**Passenger and Cargo Aircraft**Quantity limitation: 0 Forbidden **Cargo Aircraft Only** Quantity limitation: 150 kg

Section 14. Transport information

		Passenger Carrying Ship Index 65 **Passenger Carrying Road or Rail Index** Forbidden **Special provisions** 29, 42			

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): This material is listed or exempted.

Clean Air Act (CAA) 112 regulated flammable substances: propane

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Fire hazard
Sudden release of pressure

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Propane	100	Yes.	Yes.	No.	No.	No.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

Section 15. Regulatory information

New Jersey : This material is listed.

Pennsylvania : This material is listed.

International regulations

International lists

National inventory

Australia : This material is listed or exempted.

Canada : This material is listed or exempted.

China : This material is listed or exempted.

Europe : This material is listed or exempted.

Japan : This material is listed or exempted.

Malaysia : This material is listed or exempted.

New Zealand : This material is listed or exempted.

Philippines : This material is listed or exempted.

Republic of Korea : This material is listed or exempted.

Taiwan : This material is listed or exempted.

Canada

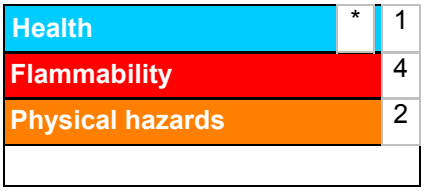
WHMIS (Canada) : Class A: Compressed gas.
Class B-1: Flammable gas.

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

Canada Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.

Hazardous Material Information System (U.S.A.)



Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)

Section 16. Other information

Procedure used to derive the classification

Classification	Justification
Flam. Gas 1, H220 Press. Gas Liq. Gas, H280	Expert judgment Expert judgment

History

Date of printing : 10/20/2015

Date of issue/Date of revision : 10/20/2015

Date of previous issue : No previous validation

Version : 0.01

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Other special considerations : The information below is given to call attention to the issue of “Naturally occurring radioactive materials”. Although Radon-222 levels in the product represented by this MSDS do not present any direct Radon exposure hazard, customers should be aware of the potential for Radon daughter build up within their processing systems, whatever the source of their product streams. Radon-222 is a naturally occurring radioactive gas which can be a contaminant in natural gas. During subsequent processing , Radon tends to be concentrated in Liquefied Petroleum Gas streams and in product streams having a similar boiling point range. Industry experience has shown that this product may contain small amounts of Radon-222 and its radioactive decay products, called Radon “daughters”. The actual concentration of Radon-222 and radioactive daughters in the delivered product is dependent on the geographical source of the natural gas and storage time prior to delivery. Process equipment (i.e. lines, filters, pumps and reaction units) may accumulate significant levels of radioactive daughters and show a gamma radiation reading during operation. A potential external radiation hazard exists at or near any pipe valve or vessel containing a Radon enriched stream, or containing internal deposits of radioactive material due to the transmission of gamma radiation through its wall. Field studies reported in the literature have not shown any conditions that subject workers to cumulative exposures in excess of general population limits. Equipment emitting gamma radiation should be presumed to be internally contaminated with alpha emitting decay products which may be a hazard if inhaled or ingested. Protective equipment such as coveralls, gloves, and respirator (NIOSH/MHSA approved for high efficiency particulates and radionuclides, or supplied air) should be worn by personnel entering a vessel or working on contaminated process equipment to prevent skin contamination, ingestion, or inhalation of any residues containing alpha radiation. Airborne contamination may be minimized by handling scale and/or contaminated materials in a wet state.

Notice to reader

Section 16. Other information

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Appendix B

Discharge Analysis and Calculations

BWL 10-05
BWL 10-14
BWL 10-13
BWL 10-01
BWL 10-03
BWL 10-02
TWP-WELL-#7
BWL 10-12
BWL 10-09
TWP-WELL-#6
BWL 10-11
BWL 10-08
BWL 10-10
BWL 10-15
TWP-WELL-#5
BWL 15-08
BWL 15-07
BWL 10-07
TWP-WELL-#4
BWL 10-06
TWP-WELL-#3
TWP-WELL-#1
TWP-WELL-#2
NO-ID

LEGEND

- MUNICIPAL WATER SUPPLY WELLS
- LOWER 1,4-DIOXANE IMPACTS > DW CRITERIA (7.2 ug/L)
- PLANT 2
- PLANT 3
- PLANT 6

WELLHEAD PROTECTION AREAS

- LANSING TOWNSHIP
- CITY OF LANSING

0 870 1,740

SCALE IN FEET

Source: Esri, DigitalGlobe, Ge
Getmapping, Aerogrid, IGN, IG

RACER TRUST
LANSING, MICHIGAN

MUNICIPAL WATER SUPPLY AND WELLHEAD PROTECTION AREAS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
B-1

CITY: Novi DIV: ENV DB: TRY PIC: PM: TM: TR: PROJECT NUMBER: COORDINATE SYSTEM: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl
G:\GIS\Project Files\MotorsLiquidationCompany\Lansing\Docs\working\Lansing WHPAs.mxd PLOTTED: 5/19/2016 7:18:58 PM BY: dolexa

INJECTION RECEPTOR ANALYSIS

Groundwater in the weathered bedrock encountered at the Site is not used as a drinking water source; there are no drinking water wells located on Site. However, the Site is located partially within a wellhead protection area, and the bedrock aquifer below the weathered bedrock is used as a drinking water source for the City of Lansing and Lansing Township. The biosparge area is outside the wellhead protection area for Lansing Township and City of Lansing. The locations of the municipal water source wells and wellhead protection areas relative to the Site and treatment area location are shown on Figure B-1.

The sand lens installation process is a controlled process that will create a single lens, which is propagated horizontally by the injection of the sand mixture. By injecting a sand solution focused on a particular interval that has been notched/opened using water jetting techniques, the location of the sand lens is vertically controlled. By injecting at relatively low pressures (entry pressure and below), the propagation of the fracture is limited in horizontal extent. Based on the characteristics of the weathered bedrock formation and experience in similar geologic settings, it is expected that a 15-foot radius is achievable, and that the sand lenses are not expected to exceed a 50-foot radius. The biosparge points are located more than 400 feet from the site boundary; therefore, the lenses will be contained well within the Site boundaries.

Municipal water wells are generally installed as open bedrock wells with total depths of 400 to 500 feet below grade. The well casings are generally set at 50 feet or more into bedrock to assure well stability. Lansing Board of Water and Light personnel have indicated that these wells are typically capable of pumping several hundred gallons per minute.

A transducer survey was completed at the Site to evaluate the hydraulic connection between the monitoring wells installed along the lower 1,4-dioxane plume and the municipal pumping wells. The results of the study show a hydraulic response at several bedrock wells located near the lower 1,4-dioxane source area at Plant 3. The highest amplitude of response was observed due to the pumping at Lansing Township Well #4, located approximately 1,000 feet west of the “coliseum” area (Figure B-1). However, bedrock in the 1,4-dioxane source area is not impacted above criteria, and operation of the municipal wells does not appear to affect the distribution of the lower 1,4-dioxane plume within the weathered bedrock zone (Arcadis 2015).

Because the municipal wells have not affected the distribution of the lower 1,4-dioxane plume over many years, they are unlikely to affect the distribution of injected propane and oxygen. Microbes will consume the majority of the injected propane and the remaining propane is expected to dissipate rapidly within the formation, which will be confirmed by post injection propane dissipation testing as discussed above. During the 2016 and 2017-2018 biosparging pilot tests, dissolved propane levels at MW-16-75, the outer down-gradient monitoring well located closest to the Site boundary (215 feet from the boundary), were consistently below 4 µg/L (versus up to 360 µg/L in the sparge points during the 2016 pilot and up to 43 µg/L nearby monitoring wells during the 2017-2018 pilot). Based on seepage velocities for the biosparge area estimated to range from approximately 0.5 feet per day (ft/d) to 2.0 ft/d (Arcadis 2016), dissolved propane is not expected to migrate off-site or pose any threat to the off-site municipal wells.

Utilities within the injection areas or immediately downgradient of the injection area are shallow and typically less than 30 bgs. Due to the depth of the proposed injection (greater than 65 feet bgs), the dissolved propane will not contact any underground utilities or pose a threat to surface water.

Estimated Injection Discharges

The estimated potential injection concentrations during the biosparge system operation are as follows:

1. Galactasol® powdered guar bean flour

    - Galactasol powdered guar bean flour will be mixed with water to form guar gum and injected into the propagated fractures as a carrier fluid for the quartz silica sand. Fifteen to 17 pounds of guar gum will be injected per sand lens and is anticipated to break down to carbon dioxide and water and dissipate into the formation within 48 hours of injection. The mass of guar gum injected may vary based on sand lens thickness, but the concentration will remain approximately constant (only the sand content of the sand mixture may vary). TOC concentrations may temporarily be increased because of the injection, but are expected to return to baseline levels as the carbon is consumed by microorganisms.

2. LEB-H – endo-1,4-R-mannase

    - A total of one ounce of LEB-H will be injected as a component of the sand mixture into each biosparge point during the initial bioaugmentation event as an enzyme to break down the Galactasol®. Any residual LEB-H is expected to biodegrade in-situ.

3. Borax

    - Up to approximately one pound of Borax (sodium tetraborate decahydrate) will be injected per sand lens with the sand and Galactasol®. The purpose of the Borax is to strengthen the three-dimensional structure of the guar gum. The Borax injection concentration will remain relatively constant even if the total injection volume is increased or decreased based on field conditions.

        - The estimated boron concentration is approximately 28,480 µg/L based on an anticipated fluid injection volume of 200 gallons per sand lens and a conservative dilution factor of two upon injection. This concentration exceeds the MDEQ Part 201 2013 drinking water criteria (500 µg/L for residential and non-residential) and draft 2017 criteria (800 µg/L for residential and 3,300 µg/L for non-residential). Arcadis monitored boron concentrations in selected wells before and after the 2017-2018 Pre-Design Study. Boron was not detected above criteria in the pilot test area or surrounding area and as such, boron is not included in the sampling plan for full scale operation.

        - The estimated sodium concentration upon injection is 130,193 µg/L, which exceeds the 2013 MDEQ Part 201 Residential Drinking Water Criterion of 2,300 µg/L. However, because the concentration does not exceed the 2013 Non-Residential Criteria or the proposed 2017 criteria, sodium concentrations will not be monitored before or during system operation.

4. Diammonium Phosphate

    - A one-time injection of approximately 175 to 200 gallons of DAP solution may be injected into each biosparge point at approximately 14 grams per liter (g/L). This injection volume assumes two (2) 0.5-cm high sand lenses per biosparge point; actual volume will vary depending on the thickness of the installed sand lenses, but the target DAP concentration will remain approximately 14 g/L. Once dissolved in the groundwater and assuming a dilution factor of two upon injection, up to 5.0 g/L of phosphate (HPO_4) and 1.9 g/L of ammonium (NH_4) will be present. Based on the

2016 and 2017-2018 pilot tests, dissolved phosphate was observed at 0.7 to 3.5 g/L in the sparge points. Based on historical groundwater quality data, a negligible amount of ammonia (NH_3) may be generated in situ from the ammonium. However, the nutrients are expected to be converted by the microorganisms in-situ and are not expected to migrate outside of the treatment area. TKN will be monitored as nitrogen species production may stem from the decomposition of microorganisms in-situ. Reduced phosphorus, which is not regulated under MDEQ drinking water criteria, will dissipate through advection and dispersion.

5. Propane

- Propane will be injected via cycled operation at 0.032 to 0.074 SCFM mixed with a compressed air gas stream for a total flowrate of up to 10 SCFM 24 hours per day. This corresponds to a total propane mass loading of 1.8 to 4.1 pounds per day per biosparge point. The propane loading rate may be decreased depending on the biosparge flow rate, cycle times, and duration. Based on the 2016 and 2017-2018 biosparge pilot studies, propane concentrations in the down-gradient perimeter monitoring well were only 4 µg/L maximum.

6. Propanotroph culture ENV425

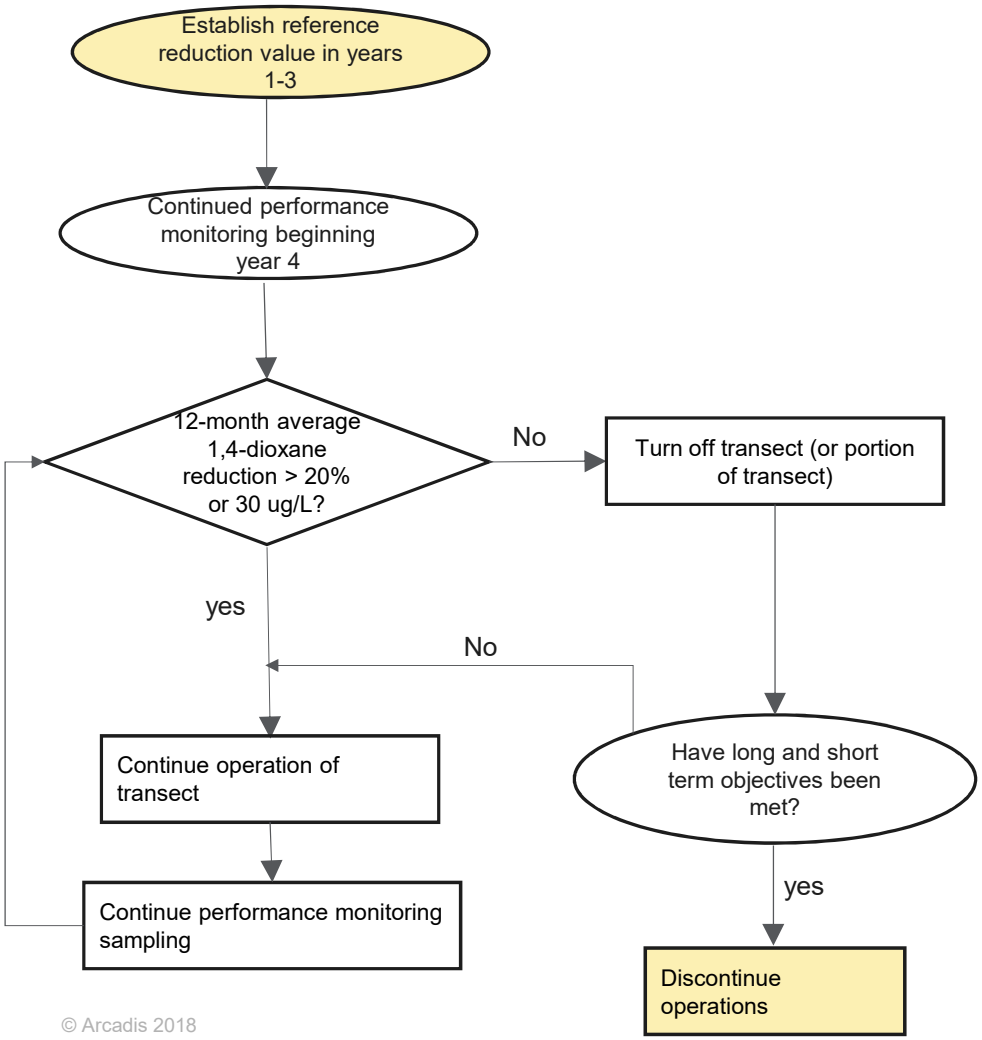
- Four (4) liters of ENV425 propanotroph bacteria culture per biosparge point may be injected into the formation. The culture consists of microbial communities in a water-based medium. The culture is comprised of microbes that will not become invasive or damage the native microbial community, and will perish once oxygen, propane, and nutrient injections are discontinued.

As discussed above, these materials will be injected in small quantities and are expected to be diluted, consumed or dissipate within the formation shortly after injection, therefore migration outside the treatment area is not anticipated.

Appendix C

Performance Monitoring Decision Tree

RACER Lansing Biosparge Decision Flow Chart

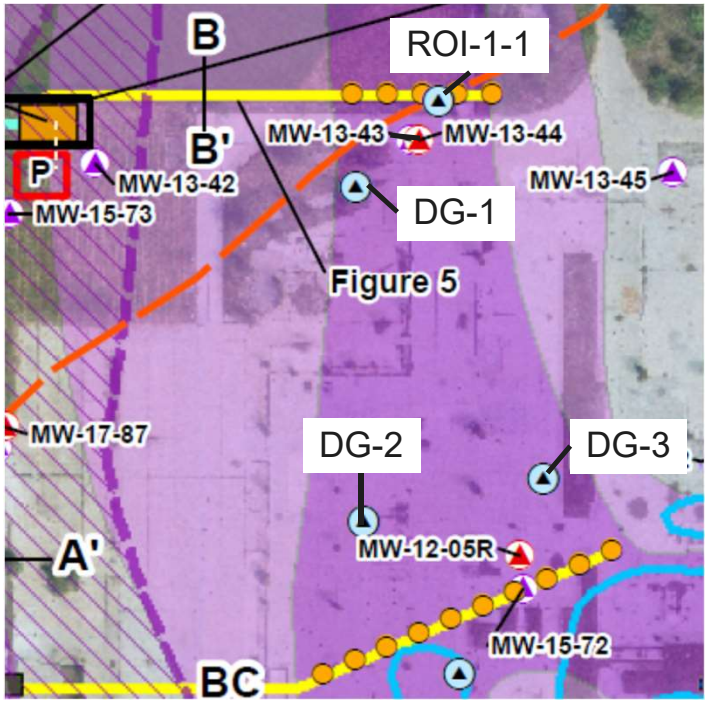


RACER Lansing Biosparge Decision Flow Chart – Example Scenario

Step 1 – Establish reference reduction value

Year	Date	Well 1,4-Dioxane (µg/L)					Average (µg/L)	Average 12-month Reduction (µg/L)*
		13-43	ROI-1	DG-1	DG-2	DG-3		
1	3/2020	400	330	350	370	370	364	--
	6/2020	370	240	345	368	372	339	--
	9/2020	320	150	340	372	359	308	--
	12/2020	270	40	325	365	364	273	--
2	4/2021	240	12	320	360	367	260	104
	10/2021	210	8	290	340	342	238	70
3	6/2022	172	7	265	290	285	204	56

Reference reduction value = 104 µg/L per year



*Average 12-month reduction in year n = (Avg conc of transect wells in year n) – (Avg conc of transect wells in year n-1)

364 µg/l – 260 µg/L = 104 µg/L

308 µg/L – 238 µg/L = 70 µg/L

260 µg/L – 204 µg/L = 56 µg/L

RACER Lansing Biosparge Decision Flow Chart – Example Scenario

Step 2– Calculate 12-month average and compare to reference reduction value (104 µg/L)

Year	Date	Well					Average (µg/L)	Average 12-month Reduction (µg/L)	% of Reference Reduction Value
		1343	ROI-1	DG-1	DG-2	DG-3			
3	06/2022	172	7	265	290	285	204	56	54%
4	06/2023	144	3	210	225	235	164	40	39%
5	06/2024	112	3	170	190	175	130	33	32%
6	06/2025	77	2	125	136	151	98	32	31%
7	06/2026	45	3	90	94	105	67	31	30%
8	06/2027	15	3	25	70	74	37	30	29%
9	06/2028	6	3	15	63	70	31	6	6%

By year 9, reduction is less than 30 µg/L and less than 20% of the reference reduction value.

RACER Lansing Biosparge Decision Flow Chart – Example Scenario

Step 3 – Turn off transect (or portion of transect) and evaluate if short term objective has been met:

> Short Term Objective: Reduce concentrations of Site-related 1,4-dioxane concentrations along the core of the lower 1,4-dioxane weathered bedrock plume

If yes, review lateral and vertical plume stability monitoring data for wells on perimeter of plume. Is plume stable? Have long-term objectives have been met?

> Long-Term Objectives: continued protection of the municipal drinking water supply wells by preventing Site-related 1,4-dioxane impacted groundwater from migrating off-Site laterally in the weathered bedrock zone at concentrations greater than 7.2 ug/L and reducing the potential for migration of 1,4-dioxane downward substantially into less weathered bedrock

- If yes, discontinue system operation and monitor at reduced frequency
- If no, continue operation and annual performance monitoring